Future Directions of Hip Imaging

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Disclosure

I have no financial relationships to disclose

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Imaging Considerations in the Hip

- Bony morphology and structure
- Labrum
- Articular cartilage
- Soft tissues
- Vascular structures
Bony Structure and Morphology
Bony Structure and Morphology

- Morphologic abnormalities lead to pain, limitation in activity, early osteoarthritis
  - Developmental Hip Dysplasia
  - Femoracetabular Impingement (FAI) – primary or secondary
- Qualitative and quantitative measures of femoral and acetabular morphology
- Imaging techniques: Radiographs; Computed Tomography (CT); Magnetic Resonance Imaging (MRI)
Advances in Imaging

• How effective are current imaging methods at identifying patients with morphologic hip disorders such as DDH and FAI?

• Can we do better?
Bony Structure and Morphology

- **Plain Radiographs**
  - Global assessment of morphology and alignment
  - Well-established and recognized patterns of disease
  - Highly dependent on position and technique
  - Static examination
Bony Structure and Morphology

Standard Radiographic Views

AP Pelvis

False Profile
Bony Structure and Morphology

Standard Radiographic Views

Frog-leg Lateral  Dunn lateral  Cross-table Lateral
Bony Structure and Morphology

Standard Radiographic Views

Lateral Center Edge Angle
Acetabular Angle

AP Pelvis

Anterior Center Edge Angle

False Profile
Bony Anatomy: Imaging Techniques

- **Computed Tomography (CT)**
  - High spatial resolution
  - Less dependent on patient position
  - Multiplanar reformatting

- Radiation exposure
- Static examination
Bone Imaging with CT

Semi-transparent reconstruction (quasi-radiograph)

45 rotated view (quasi false profile radiographs)
CT or Radiograph?

CT

Radiograph
CT Generated “Radiographs”
Bony Anatomy: CT Imaging Techniques

3D Reconstructions

Radial reformatting
Advances in CT: 3D Reconstructions

Segmentation of femur from acetabulum: better detail of acetabular orientation
Advances in CT: 3D Reconstructions

2D coronal CT reformat

3D segmented CT reconstruction
Future Directions in 3D Imaging

• Kinematic assessment with 3D modeling
  o Femoroacetabular impingement
  o Version assessment

• Continued dose reduction
  o Model-based iterative reconstruction (MBIR), adaptive statistical iterative reconstruction (ASIR) algorithms
Future Directions in 3D Imaging: Case Example

19 year old male ballet dancer with left hip pain and FAI
Future Directions in 3D Imaging: Case Example

19 year old male ballet dancer with left hip pain and FAI
Future Directions in 3D Imaging: Case Example

Dunn @45°
Flexion: 45° | Adduction: 20° | Internal Rotation: 0°

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Future Directions in 3D Imaging: Case Example
3D Bone Reconstructions: Limitations

Large Body Habitus (CT)

Metallic Hardware (CT/MR)
3D Bone Reconstructions: MRI

• Bone segmentation techniques
  o Labor-intensive manual segmentation
  o Computer algorithms require special software

• 3D rendering bone marrow surface
  o Thresholding techniques
  o Can be performed on many PACS workstations
Labrum
Labrum

Are labral tears becoming an epidemic?

Courtesy of Physical Therapy 2006;86:110-121
• Is there a better way to image the acetabular labrum?
Labrum

- Diagnosis usually requires MRI/A
- Evolving understanding of labral anatomy
Labrum

Superoanterior cartilage defect
Labral tear
Labrum

• What is a sulcus and what is a tear?
  o Surgeons have a hard time with this too!
  o Prospective evaluation comparing MRI to arthroscopy

• Pitfalls:
  o Normal anteroinferior sublabral sulcus at 8 o’clock
  o Normal posteroinferior sulcus/labrocartilaginous cleft (23% of individuals)
  o Anterosuperior sulci are rare (2%)…more likely a tear in this location!
  o Tears are deeper, nonlinear (sometimes), and may be associated with paralabral cyst
Labrum

Tear vs. Sulcus  Tear vs. Sulcus  Tear/Sulcus  Tear/Sulcus  Tear/Sulcus
Arthrography vs. Noncontrast MR

Direct

Indirect

Noncontrast (same patient as indirect)
Arthrography vs. Noncontrast MR

- **Indirect (PD fs)**
- **Noncontrast PD fs (same patient)**
- **Noncontrast T2 fs + Joint Effusion (same patient)**
Cam Impingement

- When is a labral tear caused by an underlying bony abnormality?
- What constitutes a true cam deformity in children/adolescents?
- Which patients need surgical intervention to prevent joint damage?
Cam-type FAI vs. Normal

Both patients asymptomatic
Cam-type FAI vs. Normal

- What is an abnormal alpha angle in an adolescent?
  * Depends on the imaging plane, physis, and gender
  * “Decreased offset” does not always = cam deformity

Cam-type FAI vs. Normal

18 year old male soccer player with hip pain
Cartilage
Cartilage Imaging

- Many ways to image cartilage:
  - 2D Morphologic Sequences
  - 3D Morphologic Sequences
  - Quantitative Imaging
- Hip cartilage is thin, curved, difficult to assess
- Sequences require both high spatial and in-plane resolution

3D SPGR
Cartilage Imaging

- 3D gradient echo imaging:
  - Fairly uniform cartilage signal
  - High spatial resolution
  - Volumetric acquisition

3D SPGR
Cartilage at 3T

3D Steady State GRE

Indirect arthrography
2D T1 or PD-weighted

Noncontrast Intermediate-Weighed 2D imaging
Cartilage Imaging at 3T

- Beware acetabular physis
Cartilage Mapping

- dGEMRIC
- T2
- T1 rho
- T2*

Increasing/shifting emphasis toward noncontrast techniques
Cartilage Segmentation/
Planar Cartilage Maps
Radiology Reporting

• Currently relies on descriptive terminology
  o More templates → match arthroscopy reports
  o Reporting by zones → standardized grading schemes
  o Less text/more schematics

Conclusions

• Future imaging directions:
  o Improved understanding of hip dynamics and how structural abnormalities affect overall joint integrity
    • 3D MRI reconstructions
    • CT generated “radiographs” and kinematic modeling
    • Improved cartilage imaging at 3T, less reliance on cartilage mapping
    • Unfolded planar cartilage maps
    • More templated reporting, similar to arthroscopy