45 year old female

- plays recreational tennis, runs marathons
- 2007: p/w several month h/o left knee pain and swelling, catching, stiffness
- PE: FROM, no instability, no effusion
- MRI to evaluate for MM tear

---

45 year old female (cont)

- at this time, pain was getting better
- conservative tx
- tripped and fell while marathon training
  2009.01.20, resumed marathon training
  2009.03, but continued pain
- PE: trace effusion, medial joint line tenderness

---

45 year old female (cont)

- arthroscopy 2009.06.01
  - medial femoral condyle cartilage defect
    - grade 4, 2.0 cm x 1.5 cm, w/ flaps
  - chondroplasty
  - microfracture for grade 4
Outline

- structure/composition
- normal appearance
- cartilage lesions
- cases
  - ACL tear
  - meniscal tear
  - OCD
- physiologic imaging

Cartilage structure and composition

- by weight
  - water (75%)
  - collagen (20%)
  - proteoglycans (5%)

Cartilage zones electron microscopy model

- leaf organization, arc morphology
- individual collagen fibers randomly oriented within the leaves
- 3D organization explains layers seen on MRI, ie via magic angle phenomenon

Imaging techniques (alphabet soup)

- morphologic
  - conventional
    - 2D FSE (T2 vs PD, +/- FS)
    - 3D SPGR FS
  - newer
    - DESS
    - DEFT
    - bSSFP
    - FEMR
    - VIPR
- physiologic
  - T2 mapping
  - Gd-(DTPA)²⁻
  - T1 rho
  - sodium
  - DWI
normal appearance
T2 FSE FS
- trilaminar
- sensitive to bone marrow edema


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T2 FSE FS
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normal appearance
PD FSE w/o FS
- routine clinical sequence
- excellent depiction of menisci, ligaments, subchondral bone

normal appearance
3D SPGR FS
- 3D, so higher spatial res’n than 2D FSE
- cartilage seen as positive contrast
- 5–13 min
- metallic artifact
- uneven fat suppression

pitfalls
magic angle
- increased T2 SI when collagen fibers 55° degrees wrt \( B_0 \)
- especially femoral trochlea and condyle
pitfalls

partial volume
- fewer laminae visible when cartilage is not perpendicular to imaging plane

chemical shift
- spatial misrepresentation when water-containing tissue is adjacent to fat-containing tissue
- occurs along the frequency-encoding axis
- can reduce with chemical shift presaturation technique

susceptibility
- gas (intra-articular nitrogen gas)
- metal (instrumentation, foreign body)
- calcium (chondrocalcinosis)
- articular surface distortion can mimic or accentuate cartilage disease

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cartilage lesions
MRI vs arthroscopy

<table>
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<th>author</th>
<th>journal</th>
<th>n pts</th>
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<td>Dister et al</td>
<td>AJR 1995</td>
<td>12</td>
<td>3D SPGR FS</td>
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<td>Dister et al</td>
<td>AJR 1996</td>
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<td>Recht et al</td>
<td>Radiology 1996</td>
<td>41</td>
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<td>81/97/97</td>
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<td>AJR 1999</td>
<td>130</td>
<td>T2 FSE FS</td>
<td>94–99/96 (cor + ax)</td>
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<td>Sonin et al</td>
<td>AJR 2002</td>
<td>54</td>
<td>PD FSE</td>
<td>59.0–73.5/86.7–90.5/79.6–86.1</td>
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cartilage lesions
MRI appearance
- normal
- increased SI
- surface irregularity
- partial thickness loss not down to bone
  - <50%
  - 50–99%
- full thickness loss down to bone
- osteocartilaginous body
cartilage lesions
MRI appearance

• normal
• increased SI
• surface irregularity
• partial thickness loss not down to bone
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• full thickness loss down to bone
• osteocartilaginous body

ACL tear and cartilage

• ACL tear assoc w/ OA, esp if there was bone bruise (>80%)
• initial blow exceeds cartilage threshold to withstand forces?
• bone heals more stiffly, so decreased compliance results in increased loads to cartilage?

outline

• structure/composition
• normal appearance
• cartilage lesions
• cases
  – ACL tear
  – meniscal tear
  – OCD
• physiologic imaging
24 year old male

• 2001:
  – lunged for soccer ball, fell on lateral R knee
  – felt a “pop,” immediate anterior pain, swelling
  – PE: effusion, swelling, pain medial joint line and w/ extension, neg drawers signs

2001.11.01

2001.11.01

2001.11.01

24 year old male (cont)

• arthroscopy 2001.12.10
  – ACL bruised but intact
  – LM tear → partial meniscectomy and synovectomy

24 year old male (cont)

• 2003:
  – re-injured knee (soccer)
  – R knee feels loose, no “locking” or “giving out,” can walk and run straight but not any side to side motion
  – PE: FROM, mild swelling, +Lachman, +anterior drawer, minimally +MCL valgus stress test

2003.02.13
24 year old male (cont)

• OR findings 2003.09.18:
  - full-thickness ACL tear → ACL-R
  - LM re-tear → partial LM-ectomy

24 year old male (cont)

• 2005:
  - reinjured knee again (basketball)
  - conservative tx, PT

• 2010:
  - ongoing knee pain, tries to ignore in gym
  - stopped PT
  - swells after sports, esp lateral movement
43 year old male

- racquetball injury 1987, ACL-R 1993
- plays hockey 2x/wk, lifts weights
- knee pain laterally and in extension, swelling
- MRI 2001: graft impingement and LM tear
- 2006: knee injury during bowling, MRI repeated

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Meniscectomy and cartilage

- 3x increased load
  - cartilage
  - subchondral bone
- decreased stability
- bottom line: OA

38 year old male

- 1989: arthroscopy
- 2007: 1 mo h/o pain after basketball w/o specific injury, joint line and behind patella, worse w/ running and getting up after sitting, swelling, buckling, locking
38 year old male (cont)

- 2008: slipped, fell, twisted knee
- PE: medial and lateral joint line tenderness, no instability
- MRI for re-evaluation

38 year old male (cont)

- arthroscopy 2008.08.20
  - medial compartment
    - complex MM tear
    - WB medial femoral condyle: diffuse grade 3 (OB)
    - medial tibial plateau: 5 mm x 10 mm grade 4 x2
  - partial MM-ectomy, chondroplasty
- 2009:
  - knee pain recurred in 2009.05
  - MRI for re-evaluation

40 year old male

- 2005: 9–10 mo h/o knee pain
- PE: tenderness medial joint line and over the medial femoral condyle
40 year old male (cont)

- arthroscopy 2005.10.14
  - distal femur cartilage intact, MM intact
  - resected hypertrophic anterior fat pad and enlarged medial plica
- pain resolved, then came back 2005.12
- multiple OSH arthroscopies, steroid injections
- injured running after dog in 2008:
  - anteromedial knee pain, “popping,” “giving way”
  - PE: medial joint line tenderness, no instability

40 year old male (cont)

- OR findings 2008.08.13
  - MM posterior third tear → MM-ectomy
  - cartilage irregularity medial femoral condyle
- 2008.10:
  - hurt knee on exercise bike during PT
  - MRI repeated

40 year old male (cont)

- multiple MD visits (2008.12, 2009.01): persistent medial joint line pain
- mid-2009: multiple knee injections (Orthovisc, Supartz) w/o improvement
- MRI repeated
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OCD

- osteochondral defect
  - valgus forces +/- rotation, deceleration
  - cartilage fissures and lacerates under loading pressure above 25 N/m²
  - location: lateral compartment

OCD

- osteochondritis dissecans
  - various theories re: etiology, including hereditary, vascular (ischemia), mechanical (trauma)
  - location: lateral aspect of medial femoral condyle

OCD

- MRI can assess:
  - integrity of overlying cartilage surface
  - bone marrow edema
  - assoc ligamentous injury
  - stability of fragment
15 year old boy

- avid BMX bike rider, performs stunts
- 1 yr h/o knee pain
- PE: small effusion, stable to varus and valgus stress, no anterior or posterior drawer sign

15 year old boy (cont)

- lost to (ortho) fu
- main issue is treatment of bipolar disorder

16 year old female

- injured knee playing softball 2009.05.12
- pain and swelling w/ activity
- PE: medial joint line tenderness, no instability
- continued pain 2009.08, so MRI
16 year old female (cont)

- OR findings 2009.09.29
  - unstable OCD medial femoral condyle
  - underwent ORIF of OCD, chondroplasty
- pt well after ORIF

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Physiologic imaging

- in animal studies, cartilage can undergo microscopic change before visible damage to articular surface (decreased PG, increased tissue hydration, altered collagen ultrastructure)
- complements morphologic imaging to evaluate GAGs and collagen matrix

- imaging techniques
  - T2 mapping
  - Gd-(DTPA)2
  - T1 rho
  - sodium
  - DWI
  - etc...


physiologic imaging

- In animal studies, cartilage can undergo microscopic change before visible damage to articular surface (decreased PG, increased tissue hydration, altered collagen ultrastructure)
- Complements morphologic imaging to evaluate GAGs and collagen matrix


summary

- Traumatic or sports injuries can hasten cartilage damage
- Conventional clinical MRI sequences are excellent at depicting cartilage lesions
- Newer physiologic imaging techniques may identify microscopic damage before morphologic changes occur

references