Background and Significance

Osteoarthritis

More than 20 million in US
80-90% > 65 yo

Major cause of:
Work disability
Reduced quality of life

U.S. Centers for Disease and Control Prevention, www.cdc.gov
The study authors said increased awareness and better screening to identify patients with osteoarthritis may help delay disease progression and resulting disability, thus reducing medical costs.
Background and Significance

Whole joint concept

Cartilage and meniscus pathology contribute to osteoarthritis

Hypothesis: Better visualization will lead to improved patient care
Visible Long T2

Invisible Short T2

<table>
<thead>
<tr>
<th>Tissue or tissue component</th>
<th>Mean $T_2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deep layers of articular cartilage</td>
<td>5–10 ms</td>
</tr>
<tr>
<td>Knee menisci</td>
<td>5–8 ms</td>
</tr>
<tr>
<td>Patellar tendon</td>
<td>4–10 ms</td>
</tr>
<tr>
<td>Achilles tendon</td>
<td>0.25 and 0.7 ms, 1.2 ± 0.2 ms, 0.53 ms (88%), and 4.8 ms (12%), 7 ms</td>
</tr>
<tr>
<td>Cortical bone</td>
<td>0.4–0.5 ms</td>
</tr>
<tr>
<td>Dentine</td>
<td>0.15 ms</td>
</tr>
<tr>
<td>Dental enamel</td>
<td>70 μs</td>
</tr>
<tr>
<td>Protons in water tightly bound to proteins</td>
<td>10 μs</td>
</tr>
<tr>
<td>Protons in proteins</td>
<td>10 μs</td>
</tr>
<tr>
<td>Protons in solids, e.g. calcium hydroxyapatite</td>
<td>1 μs or less</td>
</tr>
</tbody>
</table>

Conventional MRI vs UTE T1rho

Meniscus

Transverse magnetization decay

Majority of short T2 components

Minority of Short T2 components

Robson, Bydder. J Comput Assist Tomogr 2003
**Musculoskeletal short T2 tissues**

<table>
<thead>
<tr>
<th>Table 3: Normal (Adult) Tissues with a Majority of Short T2 Components</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meninges (dura)</td>
</tr>
<tr>
<td>Membranes</td>
</tr>
<tr>
<td>Retinaculi</td>
</tr>
<tr>
<td>Sheaths</td>
</tr>
<tr>
<td>Aponeuroses</td>
</tr>
<tr>
<td>Menisci</td>
</tr>
<tr>
<td>Bone</td>
</tr>
<tr>
<td>Falx</td>
</tr>
<tr>
<td>Capsules</td>
</tr>
<tr>
<td>Septae</td>
</tr>
<tr>
<td>Nails</td>
</tr>
<tr>
<td>Tendons</td>
</tr>
<tr>
<td>Labrii</td>
</tr>
<tr>
<td>Dentine</td>
</tr>
<tr>
<td>Tentorium</td>
</tr>
<tr>
<td>Bands</td>
</tr>
<tr>
<td>Fascae</td>
</tr>
<tr>
<td>Hair</td>
</tr>
<tr>
<td>Ligaments</td>
</tr>
<tr>
<td>Periosteum</td>
</tr>
<tr>
<td>Enamel</td>
</tr>
</tbody>
</table>

Robson, Bydder. J Comput Assist Tomogr 2003
Musculoskeletal short T2 tissues
Musculoskeletal short T2 tissues

Collagen

Proteoglycan

T2

T1rho
dGEMRIC
Na
Purpose

Demonstrate clinical applications of UTE quantitative MRI
Novel MRI techniques can be utilized to quantify microstructural changes.

- DIR UTE
- UTE T1 rho
- UTE T2*

Early detection and quantify response to treatment.
UTE pulse sequence

Robson MD, Bydder GM. NMR Biomed 2006.
Radial K-space acquisition

Robson MD, Bydder GM. NMR Biomed 2006.
UTE T1 rho

Spin-lock pulse

UTE Clinical Applications

Articular Cartilage
  Patella
Fibrocartilage
  Intervertebral disc
  Temporomandibular joint
  Triangular fibrocartilage complex

Meniscus

Bae, Du, Bydder, Chung. TMRI 2010.
Protocol for MRI of cartilage

Cartilage composition

Extracellular matrix
- Tissue fluid
  - Water (65-80%)

Macromolecules
- Collagen II (15-25%)
- Proteoglycans (3-10%)
- Non-collagenous proteins

Chondrocytes (1%)

Histology
Articular Cartilage

Bae, Du, Bydder, Chung. TMRI 2010.
3D DIR UTE
Contrast for calcified cartilage

Bae, Du, Bydder, Chung. TMRI 2010.
UTE Clinical Applications

Articular Cartilage
- Patella

Fibrocartilage
- Intervertebral disc
- Temporomandibular joint
- Triangular fibrocartilage complex

Meniscus

Bae, Du, Bydder, Chung. TMRI 2010.
Lumbar disc
Normal vs. Degenerate

Bae, Chang, Chung. EMR 2012.
Short TE
Annulus fibrosus

Bae, Chang, Chung. EMR 2012.
Short TE
Annulus fibrosus

Bae, Chang, Chung. EMR 2012.
UTE and magic angle effect
Temporomandibular joint disc

Bae, Chang, Chung. EMR 2012.
Temporomandibular joint

Bae, Chang, Chung. EMR 2012.
Short TE

Triangular fibrocartilage complex

Bae, Chang, Chung. EMR 2012.
UTE Clinical Applications

Articular Cartilage
- Patella

Fibrocartilage
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Bae, Du, Bydder, Chung. TMRI 2010.
Meniscal structure

Fibrocartilage
- Water ~75%
- Collagen fibers ~20%
  - Type I: ~90%
  - Type II: Inner portion
Proteoglycans
- Inner portion
Elastin
Cells

Collagen fiber pattern
- Circumferential
- Majority of fibers
- Radial
- Meshwork (Perforating-Random)

Electron microscopy
Posterior horn of medial meniscus

Electron microscopy
Posterior horn of medial meniscus

Electron microscopy
Posterior horn of medial meniscus

Medial meniscus enthesis

Tissue types

Medial meniscus enthesis
Type 1 vs Type 2 collagen

Novel MRI techniques can be utilized to quantify microstructural changes. 

UTE T2*  
UTE T1 rho  

Early detection and quantify response to treatment
Case presentation

Clinical history

24 year old male with knee pain
LINSANITY!
Jeremy Lin lights up the NBA
By Sean Gregory
NEW YORK -- Jeremy Lin will have left knee surgery next week and will miss six weeks, likely ending his amazing breakthrough season.
Knicks' Lin won't play with knee at '85 percent'
By MARC BERMAN
Posted: 11:44 AM, May 9, 2012
Knicks must let Jeremy Lin go
Nothing personal -- he's just not worth the money. Let the sanity begin!

By Stephen A. Smith | ESPNNewYork.com  
Updated: July 17, 2012, 12:16 PM ET

Jeremy Lin has been all about the money since the day he burst onto Broadway. He definitely was overcome by dollar signs when he wouldn't play at "85 percent" for the New York Knicks in the playoffs, and it was all about the bottom line once free agency arrived.

Quantitative MRI can quantify response to treatment
Tear
Degeneration
Calcification
R.I.P. LINSANITY
BRIEFLY BELOVED BROADWAY SMASH HIT
FEBRUARY 4, 2012 TO MARCH 14, 2012

Woodson: This is the Melo and Amar’e show now

New Knicks coach Mike Woodson made it clear at practice yesterday that the Jeremy Lin era is history and that Carmelo Anthony and Amar’e Stoudemire will become the focus of the team’s offense. Berman / PAGES 112-113
Short TE
Meniscus

Bae, Du, Bydder, Chung. TMRI 2010.
Short TE
Meniscus

Bae, Du, Bydder, Chung. TMRI 2010.
Meniscus
TE times

Bae, Chang, Chung. EMR 2012.
UTE T1 rho
Meniscal tear
UTE T2\* 
Meniscal degeneration
UTE T2* vs T2

Normal vs degeneration vs tear

UTE T2* more sensitive in identification of pathology than T2 values (p=0.03)
UTE T1 rho vs T1 rho

Normal vs degeneration vs tear

No statistical significant difference between groups
UTE T2*

Posterior horn medial meniscus

UTE T2*

Posterior horn medial meniscus

3D UTE
Meniscal calcifications

UTE and subtraction
Meniscal calcifications vs gas

Meniscal calcifications

UTE qMRI can distinguish and quantify:

- Proteoglycan integrity
- Collagen organization
- Microcalcifications

Clinical applications include characterization of short T2 tissues
Future Directions

Tear of posterior horn of medial meniscus with involvement of posterior root ligament
Future directions

Evaluate normal root ligament morphology through UTE MRI and correlate with histology

Chung, et al. 2013
Future directions

A. Coring

Cartilage/Bone characterization by 3D UTE

****Core aquisition for project that will explore Bone cartilage interface

B. Root Ligament

1” Coil Placed On Top

morphologic & qMRI:
- distinguish R.L. from meniscus
- qMRI of root ligament
--orientation to B0 as patient would be placed (perpendicular to bore)

C. Biomechanics

root ligament on AHLM or PHMM

Footnote

Chung, et al. 2013
Collagen Network
Transition from Meniscus to Root Ligament

Axial

Sagittal

Chung, et al. 2013
Conclusion

UTE allows visualization of “MRI invisible” short T2 structures.

Menisci are composed of collagen and proteoglycans, and microstructural changes can lead to altered joint mechanics, predisposing to osteoarthritis.

UTE T2* and UTE T1 rho are novel MRI pulse sequences that can detect microstructural changes, which could lead to early diagnosis and quantification of response to treatment.
Thank you

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UCSD MSK Radiology


