Contemporary Imaging for Arthritis

Disclosures

None

Contemporary Imaging for Arthritis

• What is the lowest outside temperature ever recorded in Indianapolis on November 07?
  • 28
  • 20
  • 17
  • 12


Contemporary Imaging for Arthritis

• In what year was the lowest temperature ever recorded in Indianapolis on November 07?
  • 2001
  • 1983
  • 1971
  • 1965


Contemporary Imaging for Arthritis

• Lowest temperature 20 F.
• November 07, 1971

Arthritis Burden USA

• 50% 85 y/o knee OA
• 25% during life hip arthritis
• 52 million doctor dx arthritis
• 67 million doctor dx arthritis by 2030
Arthritis Types

- Osteoarthritis
- Rheumatoid arthritis
- Crystal diseases
  - Gout
  - Pseudogout (*Ca++ Pyrophosphate Dihydrate Crystal Deposition Disease*)
- Spondyloarthropathies
  - Ankylosing Spondylitis
  - Psoriasis

Arthritis Risk Factors

- Age
- Weight
- Inflammatory diseases
  - Psoriasis
  - Inflammatory bowel disease
- Unknown

The Obesity Epidemic

- Try hard not to embarrass anyone
- I struggle with weight just like you
  - My metabolic rate crashed about 20 years ago
- Before you knew me, I weighed another 20#
- Major risk factor for arthritis

The Obesity Epidemic

*It is getting worse*

- Worldwide issue
- Obesity > hunger

US Population Weight Change 1960-2012

Knee and Hip Arthritis Risk Factors

*Overweight and Obesity*

- 66% w/ MD Diagnosed arthritis overweight/obese
- MD diagnosed arthritis
  - 22.6% overweight
  - 31.2% of obese
  - 15.9% under/normal weight
- Wt loss ~11# decreases risk knee arthritis 50%
- Wt loss 10% decreases knee pain
- Costs:
  - Over 100 billion 2020
  - $80.8 billion 2003
  - $51.1 billion in 1997
- Arthritis most common cause disability 15 years
Arthritis Management
25 years

- Inflammatory Symptomatic
  - Salicylates
  - Paraffin baths
  - Braces
- Crystalline-gout
  - Dietary Management

2015
- Break inflammatory cycle
  - NSAIDs
  - DMARDs
  - Biologic
    - Anti tumor necrosis factor
    - Anti cytokine antibodies
- Crystalline-gout
  - Alter metabolic pathway
    - Allopurinol
    - Uloric

Poll Everywhere
As of 2012, what % of the US population is overweight/obese
- 50%
- 60%
- 70%
- 90%

Cartilage imaging
Review cartilage anatomy
Review surgical repair

Hyaline Cartilage Anatomy

- Chondrocytes
  - Lacunae
  - Make ground substance
    - Fibrous
      - Collagen fibrils
    - Type II collagen
  - Amorphous
    - Glycosaminoglycans (GAGs) aka Proteoglycans
  - No nerves, lymphatics, blood vessels
  - Arranged into zones

Hyaline Cartilage Anatomy

Glycosaminoglycan
- Negatively charged
- Proteoglycan aggregate

GAGs are the walls of the cartilage sponge
Their function is to hold water and act as a baffle
Cartilage Disorders

- Abnormal cartilage is a common finding
- Lesions range from small to large, focal to diffuse
- Line between isolated cartilage lesion and osteoarthritis not clear
- Multiple techniques for evaluation
- Evaluate cartilage MORPHOLOGY 98%

Cartilage Damage

How do you get it?

- Cartilage responds to
  - Compressive forces
    - This is a normal force
    - Knee cartilage compresses 3-10%
    - Talar cartilage compresses 5-35%
  - Shear forces
    - These are abnormal forces
    - Knee cartilage shift 5.6% @ surface
    - W/ degeneration shift 28% @ surface

Cartilage Damage

Treatments-Surgical

- Debridement
- Microfracture
- Cartilage transplantation
  - Mosaicplasty-Autograft, allograft
    - Move plugs of bone/cartilage; 1 surgery
    - Defect <5.0 cm²
  - Autologous chondrocyte implantation
    - Harvest, grow, transplant; 2 surgeries

Cartilage Damage

Treatments-Surgical

- Cartilage debridement/microfracture
  - >1million/year
- Knee replacements: 800,000/year
- Hip replacements: 450,000/year

Cartilage Repair

Microfracture

- Most commonly performed procedure
- Debride unstable cartilage
  - Down to subchondral bone plate
- Create holes in bone plate
  - Drills, awls
- Clot into bone/cartilage bowl
- Non weight bearing 6 wks
- Passive ROM

Microfracture

Results in fibrocartilage covering
Cartilage Repair

Mosaicplasty

- Mosaicplasty - Autograft, allograft
  - Move plugs of bone/cartilage; 1 surgery
  - Defect <5.0 cm²

Mosaicplasty

Results in articular cartilage covering

Poll Everywhere

Microfracture results in which of the following defect coverages

- Hyaline cartilage
- Fibrocartilage
- Collagenous scar tissue
- Bone

Osteoarthritis

Surgical Treatment - Knee Prosthesis

- All three compartments
  - Most common procedure
- Two compartments
  - Femorotibial articulation
  - 1 femorotibial and patellofemoral
- Single compartment

Osteoarthritis

When to replace knee

- When the patient wants it
- Pain and disability interfere with lifestyle

Cartilage Visualization

Indirect

- Historically use radiographs
- Joint space narrowing is surrogate for cartilage loss
- Poor correlation w/ early cartilage damage
Cartilage Visualization

Direct

- Magnetic resonance imaging
- Ultrasound
- Computed tomography arthrography
- Radiographic arthrography

Direct Cartilage Assessment

Magnetic resonance imaging

Anatomic Evaluation
- PD
- PD fatsat
- STIR
- T2
- Gradient echo T2

Histochemical Evaluation
- T2 mapping
- T1ρ
- dGEMRIC
- Sodium imaging
- Diffusion weighted Imaging

Magnetic resonance imaging

Anatomic Evaluation

PD
TE 20 TR 2500

PD
TE 20 TR 2500

T2
TE 77 TR 2380

STIR
TE 51 TR 3330 TI 210

GR
TE 15 TR 400 FA 15

GR
TE 15 TR 400 FA 15

GR WE DESS
TE 5 TR 15

Cartilage Damage

Extent of process

- Delamination tear
- Cartilage fissuring
- <50% cartilage loss
- >50% Cartilage loss
- Full thickness cartilage loss

OA Knee

MRI findings

- Cartilage missing
- Subcortical cysts
- Edema-like signal
- Other
  - Insufficiency fractures
  - Osteonecrosis

56 y/o man with knee pain

Poll Everywhere

The largest cartilage defect usually fixable by mosaicplasty is

- 4500 mm²
- 2500 mm²
- 1500 mm²
- 250 mm²
Direct Cartilage Assessment

**MRI Directs Treatment**

- If radiograph Grade IV don't need MRI

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**Osteoarthritis Two Compartments**

*Femorotibial articulation*

- Patellar cartilage OK

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**Osteoarthritis**

*Three Compartments*

TKA with patellar button

Most common replacement

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**Osteoarthritis**

*Single compartment*

51 y/o man with pain in the knee

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**Direct Cartilage Assessment**

**MRI Directs Treatment**

- Radiograph may NOT show cartilage damage
- Small cartilage defect
  - Debridement
  - Microfracture
  - Mosaicplasty
- For prosthesis, identify # regions

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**Osteoarthritis**

*Single compartment*

51 y/o man with pain in the knee
Osteoarthritis

Single compartment

- This is an age assisting bridge
- Use in younger patients 40-50
- Normal TKA lasts 18-20 years
- Harder to change to second TKA
- Unicompartmental lasts ~18-20 years
- Easier to change to full TKA

Direct Cartilage Assessment

Magnetic resonance imaging

Anatomic Evaluation
- PD
- PD fatsat
- STIR
- T2
- Gradient echo T2

Histochemical Evaluation
- T2 mapping
- T1ρ
- dGEMRIC
- Sodium imaging
- Diffusion weighted Imaging

Histochemical Cartilage Imaging

Why do it?

- Identify damage before surgical size defects occur
- Chondroprotective interventions
  - Lose weight
  - Medications
    - Statins
    - Other
      - 248 citations in PubMed for chondroprotective agents
    - Stem cells

Cartilage T2 Mapping

Early Osteoarthritis

- Early OA cartilage normal thickness to mild thinning
- T2 mapping is sensitive to collagen density and organization
- OA results in disruption of collagen matrix
- T2 mapping shows quantitative H₂O distribution
  - Relates to GAG [ ]
- Quantitative H₂O signal normally higher in radial zone
- In OA, T2 signal further increased in radial zone

Cartilage T2 Mapping

Cartilage Repair

- Osteochondral implants increased T2 early post op decreases over time

Cartilage T2 Mapping

Early Osteoarthritis

- Superficial T2 time increased in OA
- T2 more heterogeneous

Cartilage T2 Mapping

Cartilage Repair

Blue = H₂O, less GAG
Note superficial tibial cartilage
Scale = time (msec)
2014 Brown T2 Mapping osteochondral transplants JBJS
**MRI T2 Mapping**

*Confounding Factors*

- Rest / exercise
- Collagen orientation with respect to $B_0$

**Magnetic resonance imaging**

*Histochemical Evaluation-T2 Mapping*

- Need actual T2# from every voxel
- Run sequences with varying TE, long TR
- Calculate signal loss and T2’s
- Apply mapping with scale
- Segment cartilage

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**Magnetic resonance imaging**

*Histochemical Evaluation-T2 Mapping*

- Need actual T2# from every voxel
- Run sequences with varying TE, long TR
- Calculate T2’s
- Apply mapping with scale
- Segment cartilage

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**MRI Histochemical Imaging**

*Physiologic Correlates $T1_\rho$*

- $T1_\rho$ shows GAG distribution
- GAG’s motion restrict the water (Sponge walls)
- Decreased GAG in early OA in radial zone
- $T1_\rho$ relaxation rate decreases linearly with decreasing GAG content
- Pts with OA have higher $T1_\rho$ values

**Magnetic resonance imaging**

*Histochemical Evaluation-$T1_\rho$*

- $T1_\rho$ is a spin-lock sequence
- Tip the spins and hold in the $90^\circ$ plane with locking RF pulse
- Run sequences with varying TE, Short TR
- Apply mapping with scale
  - Mapit Software
- Segment cartilage

GAG distribution more superficial
Poll Everywhere
T2 cartilage mapping is most sensitive to
- Damage to the cartilage collagen
- Damage to the glycoaminoglycans
- Damage to the chondrocytes
- Damage to the calcified cartilage

Imaging for arthritis
- Evolved and evolving discipline
- No ONE technique gives all information
- New drugs and approaches to disease
- Changing disease profiles

MRI of Knee Cartilage
- Reviewed current orthopedic methods of cartilage repair/ knee restoration
- Help give perspective on place of MRI in osteoarthritis care

Thank you for inviting me