Effects of Partial Menisectomy on Tibiofemoral Kinematics and Cartilage Biochemistry: An MRI Study

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58th Annual LeRoy C. Abbott Society Scientific Program and 34th Annual Verne T. Inman Lectureship

Background

- Meniscal injury 60-70/100,000

- This changes contact forces leading to increased risk of early OA

- Total menisectomy decreases contact area 40–50% and increases contact pressure 200–300%

Cartilage Changes in Osteoarthritis

- ↓ Proteoglycan

- ↑ Water

No disclosures

Acknowledgement: Funding from Orthopedic Research Education Foundation/Goldberg Arthritis Research Grant
MRI DETECTION OF EARLY OA

- $T_2$ and $T_{1\rho}$ relaxation times reflect biochemical changes in articular cartilage\(^6\textsuperscript{-10}\)

- $\uparrow T_2$ relaxation time suggests $\uparrow$ H$_2$O content
  - Can distinguish between OA & healthy cartilage
  - $\uparrow$ H$_2$O or cartilage matrix anisotropy?

- $T_{1\rho}$ relaxation time inversely related to proteoglycan concentration

Specific Aims

**Specific Aim 1**: To compare cartilage composition before and after partial meniscectomy to determine the effects of partial meniscectomy on cartilage composition by measuring $T_2$ and $T_{1\rho}$ relaxation times

**Specific Aim 2**: To compare *in vivo* tibiofemoral kinematics within the knee before and after partial meniscectomy compared to the uninjured contralateral knee.

Hypothesis

**Hypothesis 1**: Compared to pre-operative values, subjects will show signs consistent with early OA, including increased $T_2$ and $T_{1\rho}$ relaxation times following partial meniscectomy.

**Hypothesis 2**: Tibiofemoral kinematics will be altered when measured in full extension and $30^\circ$ of flexion following partial medial meniscectomy.
Materials & Methods

Subjects:

Inclusion: 18–60y/o patients with isolated posterior horn medial meniscus tears that underwent arthroscopic partial medial meniscectomy

Exclusion: Ligamentous injury, lateral meniscus tear, history of ipsilateral knee injury, > Kellgren-Lawrence grade 1 degenerative changes pre-op, inflammatory arthritis, or injury to the contralateral knee

Materials & Methods

Imaging: Patients obtained FSE-CUBE, FSE T2, & FSE T1ρ sequences pre-operatively, 3, and 6 months post-operatively

MRI: 3T GE Signa HDx MR scanner (General Electric, Milwaukee, WI, USA)

Materials & Methods

Sub-compartmental overlay of femoral and tibial condyles. MFC = medial femoral condyle, MT = Medial tibia, c = central, a = anterior, p = posterior.

Materials & Methods

- Cartilage & Menisci were segmented using in-house software developed in Matlab (Mathworks Inc.)
- T1ρ & T2 relaxation time maps
- Menisci were segmented by 2 independent observers to determine volumes

Arthroscopic Partial Meniscectomy

- Standard AL & AM portals
- Diagnostic arthroscopy confirmed isolated posterior horn medial meniscus tear.
- Tear debrided back to a smooth & stable base
- PT started 1 week post-op
  0-2 weeks: ROM exercises
  2-4 weeks: Q/HS strengthening
  4-6 weeks: Gait & endurance
  >6 weeks: Full activity
Results – Meniscal Volume

Subjects: Nine patients (7 males; mean age, 48.6 ± 10.8 yrs; BMI = 27.3 ± 3.8 kg/m²)

Medial meniscus volume decreased 18% at 3 months and 12% at 6 months compared to pre-operative volume (p<0.001) while the lateral meniscus volume showed no significant change (p=0.813).

T1<sub>ρ</sub> Cartilage Relaxation Times

- Avg T1<sub>ρ</sub> relaxation times for the entire knee did not differ between pre-operative and 6 month post-op time points (37.3 ms vs. 38.2 ms, respectively; p=0.13)
- T1<sub>ρ</sub> relaxation time in the cMF-p increased 7.4% at 6 months (p=0.02)

T2 Cartilage Relaxation Times

- Avg T2 relaxation times for entire knee did not differ between pre-operative and 6 month post-op time points (28.4 ms vs. 29.3 ms, respectively; p=0.10)
- T2 times in the MT-c (p=0.04) & LT-c (p=0.05) tibia increased 6.3% (p=0.04) and 6.2% (p=0.05), respectively at 6 months
- T2 times in the cMF-p increased 5.1% at 6 months (p=0.22)

Tibio-femoral Kinematics

- Trend towards decreased rotation between 0° & 30° flexion at 6 months (1.3° ± 5.7° vs. 4.0° ± 5.4°; p=0.09)
- No difference in tibio-femoral translation in A-P (p=0.207) or M-L (p=0.824)
Summary

- $T_1\rho$ relaxation times were elevated in femoral articular cartilage immediately adjacent to the site of injury and meniscectomy.
- $T_2$ relaxation times were elevated in tibial cartilage-on-cartilage contact areas.
- There is a trend towards less rotation in the ipsilateral knees compared to the contralateral uninjured knees.

Limitations

- Small cohort
  - Enrolled only pts with isolated medial meniscus tears of the posterior horn
  - Likely underpowered to detect significant tibiofemoral kinematic changes
- No metrics of physical activity
  - Standardized post-op protocol
- No gait analysis
  - Would enhance our ability to understand kinematic changes
- No non-operative controls

Implications & Future Directions

- MRI is a non-invasive means to obtain in vivo cartilage biochemical changes following meniscal injury and subsequent partial meniscectomy as well as changes in meniscotibial and tibiofemoral kinematics.
- Allow earlier detection of subclinical osteoarthritis
- Facilitate study of new therapies directed at stopping or reversing arthritic changes
- Determine if there’s a critical threshold of meniscal volume that results in elevated $T_1\rho$ and $T_2$ relaxation times

Thank You!

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Acknowledgement: Funding from Orthopedic Research Education Foundation/Goldberg Arthritis Research Grant