Musculoskeletal Imaging: Osteoarthritis: Who, Where, & Why?

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Highlights

Meniscal Tears: Role in Knee Degeneration

 TARGET AUDIENCE: This course is primarily designed for radiologists, orthopaedic surgeons and clinical care providers who will benefit from knowledge on the use of MRI characteristics before and after procedures.

 OUTCOME/OBJECTIVES: At the conclusion of this lecture the participant should:

- Define the anatomy of the meniscus and the differences between the medial and lateral meniscus of the knee
- Identify the type I collagen network organization of radial tie fibers and circumferential hoop fibers and the impact of this collagen framework on patterns of meniscal tears and meniscal biomechanics
- Recognize MR imaging signs of a dysfunctional meniscus:
    - Meniscal extrusion as defined by 3 mm of displacement beyond the margin of the tibial plateau
    - Subchondral marrow edema as an indirect marker of active bone remodeling and increased loading
    - Osteochondral delamination and subchondral fracture

 PURPOSE: The purpose of this presentation is to help the interpreter of knee MRI images identify imaging findings that indicate a dysfunctional meniscus that lead to increased risk of knee osteoarthritis

 METHODS: The lecture will relate meniscal anatomy and structural organization of the type I collagen matrix in the meniscus to biomechanical function. Properties of a dysfunctional meniscus will be illustrated with clinical cases.

HIGHLIGHTS

Meniscal function is dependent on an intact system of hoop fibers that run circumferentially in the meniscus and redistribute compressive load over the tibial articular surface. When loaded a portion of the compressive force is transferred into tensile strain within the hoop fibers.

Failure of the hoop fiber network concentrates the loading forces in focal areas of the joint. Forces that exceed the material properties of cartilage damage the type II collagen network in cartilage leading to tissue loss and progressive osteoarthritis. In some cases these forces can exceed the material properties of bone leading to subchondral insufficiency fracture

The lateral compartment is more dependent on a functional meniscus. The knee is most dependent on the meniscus to redistribute load in flexion

The pattern of tear influences meniscal function. Tear patterns that transect the circumferential hoop fibers increase focal load on the articular surface and pose a greater risk for development of OA

Combination of a dysfunctional meniscus and ACL insufficiency has a synergistic risk for osteoarthritis

 LECTURE SUMMARY

Normal Meniscal Function

- Redistribute load from the femur to the tibia
- Hydraulic pressurization of synovial fluid
- Shock absorber
- Transfer of axial compressive stress to tensile strain in the hoop fibers
- Proprioception

Impact of meniscal tear

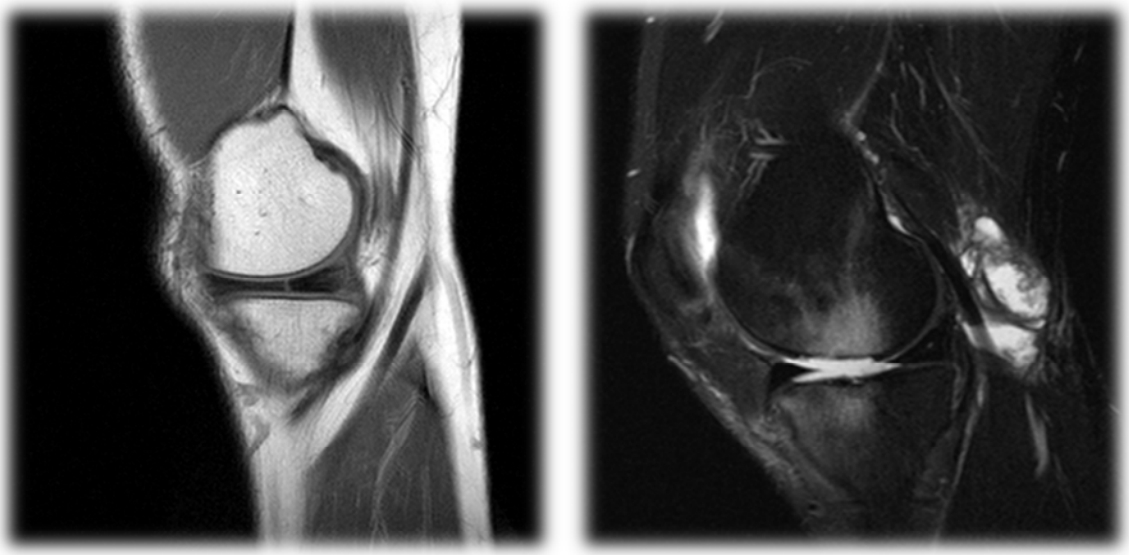
- Joint line pain
- Sensation of "locking or catching"
- Limited range of motion
- Stiffness
- Perception of instability
- Loss of normal joint mechanics leading to progressive joint degeneration
- Overloading of articular cartilage
- Subchondral fracture
- Bone remodeling

Fairbanks signs (1948)

- Ridge formation on the femoral condyle
- Joint space narrowing
- Flattening of the femoral condyle

CLINICAL EXAMPLES OF MENISCAL DYSFUNCTION

52 year old male army veteran 11 months following partial menisectomy for complex meniscal tear with worsening knee pain. Note the acute on chronic subchondral insufficiency fracture resulting from increased compressive loading of the central femoral condyle. Increased marrow signal is present throughout the femur and the periphery of the tibial plateau. Periligamentous edema of the MCL can be seen in conjunction with meniscal extrusion



37 year old soldier injured in Iraq. Initial MRI exam demonstrates a radial tear of the medial meniscus. This was not treated. Patient returns 11 months later with worsening knee pain. Subsequent MRI demonstrates propagation of the radial tear with full thickness cartilage loss of the medial femoral condyle and greater than 50% cartilage loss of the tibial plateau. There is a chronic subchondral insufficiency fracture and marrow edema secondary to excessive loading of the medial compartment

CONCLUSION

- A healthy meniscus provides an important biomechanical function distributing load across the femoral articular cartilage
- Circumferential hoop fibers are critical for restraining meniscal extrusion
- Certain patterns of meniscal tears such as traumatic longitudinal and radial tears reduce the capacity of hoop fibers to resist tensile strain
- Loss of normal meniscal function can increase the load on the articular surface by 50% to 600% leading to injury of the osteochondral plate

REFERENCES

1. Englund M, Guermazi A, Lohmander LS. The meniscus in knee osteoarthritis. Rheumatic diseases clinics of North America. 2009;35(3):579-90.
2. Bhatia S, LaPrade CM, Ellman MB, LaPrade RF. Meniscal root tears: significance, diagnosis, and treatment. The American journal of sports medicine. 2014;42(12):3016-30.
3. Guermazi A, Hayashi D, Jarraya M, Roemer FW, Zhang Y, Niu J, et al. Medial posterior meniscal root tears are associated with development or worsening of medial tibiofemoral cartilage damage: the multicenter osteoarthritis study. Radiology. 2013;268(3):814-21.