

МРТ НИЖНЕЙ КОНЕЧНОСТИ ПРИ СПОРТИВНЫХ ТРАВМАХ

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MRI OF LOWER LIMB SPORT INJURIES

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- lower limb is susceptible to injury in almost all sports
- most common cause of absence from the field of play in athletic activity dominated by lower limbs
- most frequent injuries are a consequence of overuse
- contact and noncontact trauma, especially involving the joints, leads to the longest time out of competition

MR imaging - the dominant imaging

- modality in the assessment of sports related
- Injury
- optimization of image acquisition and interpretation requires correlation with clinical findings.
- sports medicine and high-quality imaging are inextricably linked
- many findings on MRI may not represent clinically significant disorders

Structure of the radiological report

- Structures the radiological mind!
- Structures the orthopedic mind

Discuss

- causes of groin pain
- clinical, anatomical, biomechanical basis of pubalgia
- muscle injury - most common injury in lower limb dominated sports
- multiligament injury of knee
- extra-articular causes of knee pain in athletes - caused by overuse
- knee sports related cartilage injuries
- Achilles tendinopathy and peritendinitis
- overuse injuries in the foot and ankle

Etiology of lower limb pain in elite athlete

- muscle injuries
- articular
- cartilage trauma
- osseous trauma
- tendon & ligamentous trauma
- overuse bone trauma & stress fractures

referred pain

Groin Pain

- common problem in elite athlete
- lead to prolonged inactivity if inadequately treated

Aetiology:

- Articular
- Osseous/Tendo-osseous
- Muscular
- Paratendinous/Bursal

Pelvic Overuse Injury

- 5-6% athletic injury in adults
- 10-24% athletic injury in children
- lower limb dominated athletic activity
- football, rugby, running, ballet
- MRI global view bone and soft-tissue
- IV gadolinium
- MR arthrography

CLINICAL ASSESSMENT OF GROIN PAIN

- Acute pain - labral, muscular, ligamentous tears, osteitis pubis, tightness of hip capsule
- Acute or chronic pain - stress fracture, muscle tear
- Chronic pain - posterior wall insufficiency, pubalgia
- Difficulty with sprinting - post abdominal wall insufficiency
- Pain on kicking - muscular injuries
- Pain on twisting - labral or sacroiliac pathology
- Pain during landing - stress fracture, inflammation of sacroiliac joint
- Night pain - systemic cause
- Pain or stiffness in the morning - degenerative, inflammatory etiology.

Groin pain MRI imaging

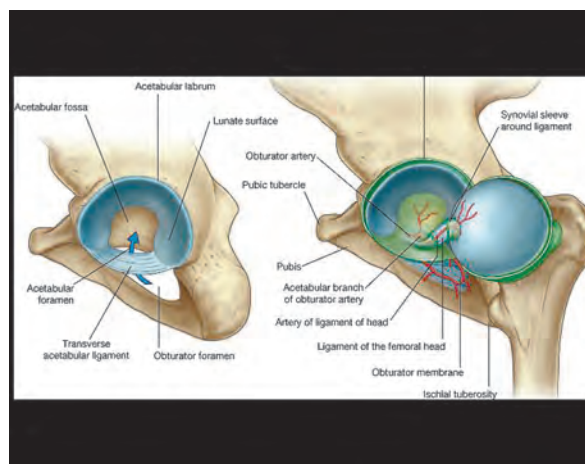
- soft tissue contrast resolution, multiplanar capabilities, wide FOV for potential causes of groin pain
- MRI and MR arthrography articular, osseous, tendinous, and muscular structures
- hip joint, pelvic bones and proximal femoral, pelvic tendon attachments, pelvic musculature

Articular injury

- hip ligament tears
- labral tears
- femoroacetabular impingement
- osteochondral injuries
- transient bone marrow oedema

Intrinsic Ligament Injury

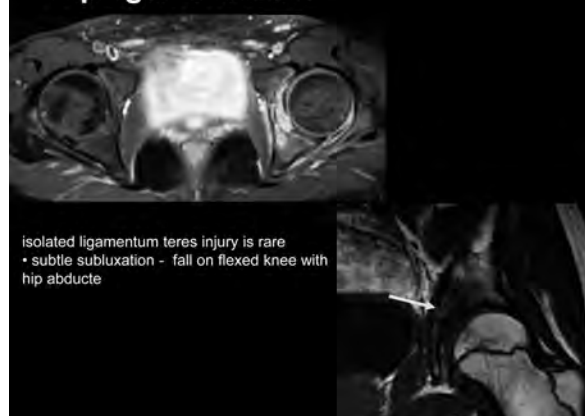
- isolated ligamentum teres injury rare
- subtle subluxation - football, gym, rugby
- fall on flexed knee with hip abducted
- posterior acetabular fracture
- only 5% diagnosed pre-arthroscopy



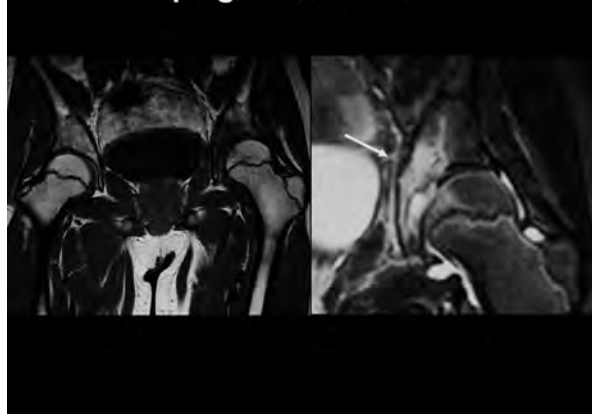
Ligamentum teres injury



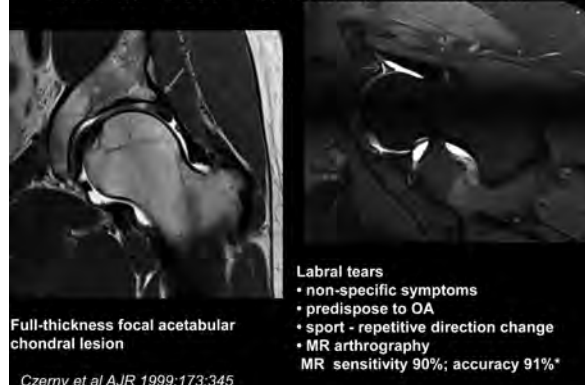
Hip ligament tears



Hip ligament tears



Labral tear & chondral lesion



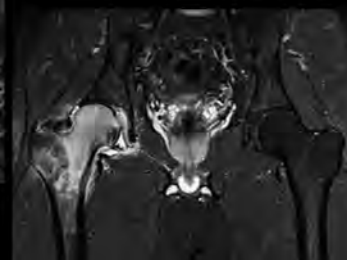
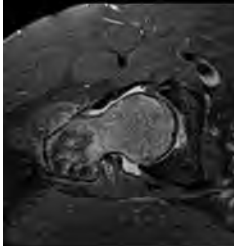
Paralabral cyst

- paralabral cyst - increases specificity



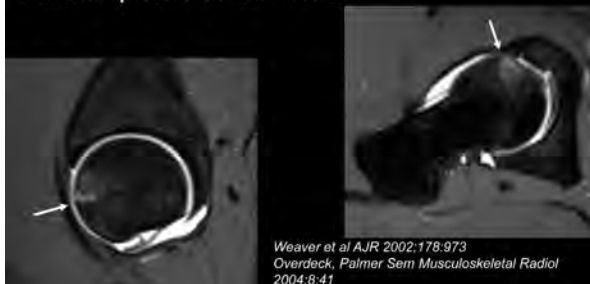
Transient Bone Marrow Oedema

- Self limiting bone marrow oedema and synovitis in the hip
- Osteopaenia and insufficiency fractures
- Young males following sports injury
- Pregnancy, middle age F>M
- May be a continuum to ischaemic necrosis
- Treated with bisphosphonates



Osteochondral injuries

- repetitive microtrauma
- subclinical shearing/impaction injury
- subtle hip instability - contact sports
- often superomedial femoral head



Osseous/Tendo-Osseous Injury

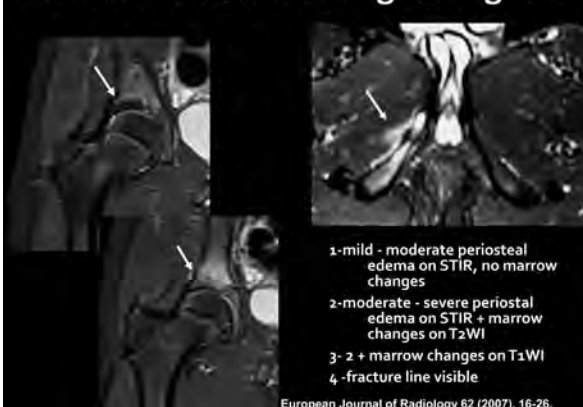
- osseous injury
- stress response/fracture
- tendo-osseous injury
- apophyseal injury
- enthesopathy
- tendon avulsion

Stress Fracture

- 20% all injuries in sports related trauma
- normal bone subject to abnormal forces
- prox femur, pubic rami, sacrum
- risk factors
- female > male 1.5-3.5 : 1
- declining fitness with age



Stress Fracture-MRI grading sm



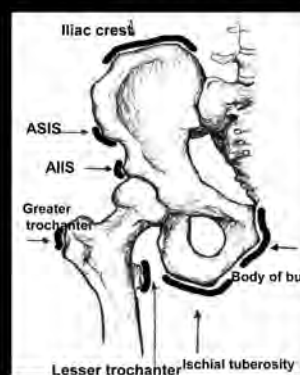
Tendo-osseous injury

developing skeleton - physis/apophysis

- stress response
- apophyseal avulsion
- mature skeleton - entheses
- enthesopathy
- tendon avulsion
- tendon and bony avulsion



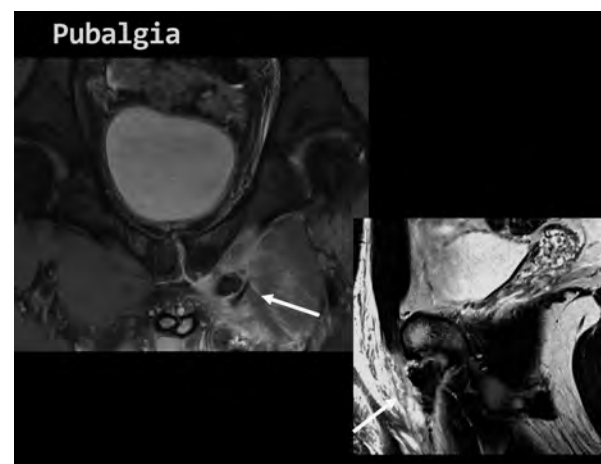
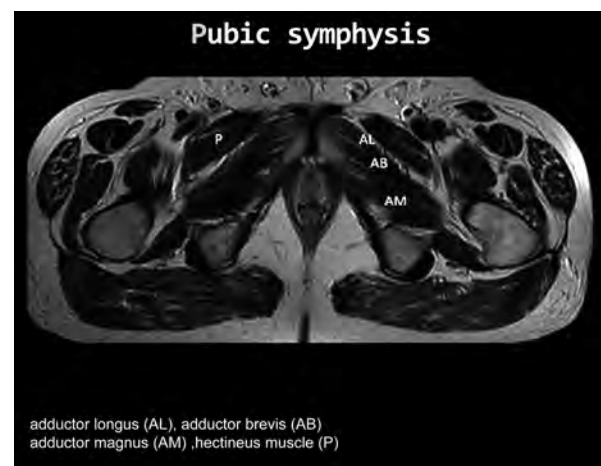
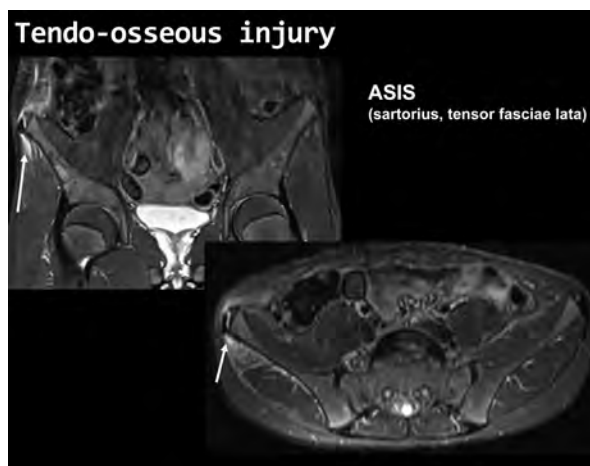
Tendo-osseous injury



- Ischial tuberosity (hamstrings)
- AIIS (rectus femoris)
- ASIS (sartorius, tensor fasciae lata)
- pubic symphysis (adductors, gracilis)
- Lesser trochanter (iliopsoas)
- Iliac crest (abdominal muscles)
- Greater trochanter (hip rotators)

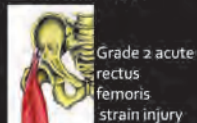
C. LaBella, Clin Ped Emerg Med 8:31-42 * 2007

Rossi, Dragoni Skeletal Radiol 2001;30:127



Muscle traumatic injuries

- football/soccer - 92% affect the four major muscle groups of lower limbs:
hamstrings 37%, adductors 23%, quadriceps 19%, calf muscles 13%



- 96% of muscle injuries in football/soccer in non-contact situations
- contusions - frequently in contact sports - rugby, American football, ice hockey.
- 16% of muscle injuries in elite football/soccer are re-injuries & associated with 30% longer absence from competition

Quadriceps Strain

Mueller-Wohlfahrt H-W, et al. Br J Sports Med 2013;47:342-350.

Muscle traumatic injuries

DIRECT MUSCLE INJURY

- **Muscle contusion** due to direct trauma of the muscle against a hard surface and the bone they are common in contact sports
- **Muscle laceration**: it results from penetrating injuries and it is seen more frequently in polytraumatized patients. It is uncommon in sports injuries.



Morel-Lavallée lesion

Muscle traumatic injuries

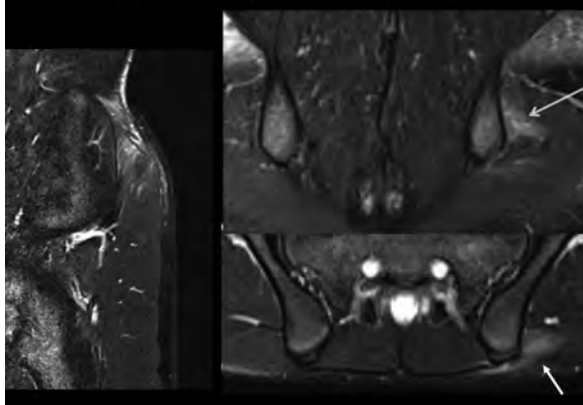
INDIRECT MUSCLE INJURY

- usually close to the muscle-tendon junction (rectus femoris, hamstrings and gastrocnemius)

Elongation injuries:

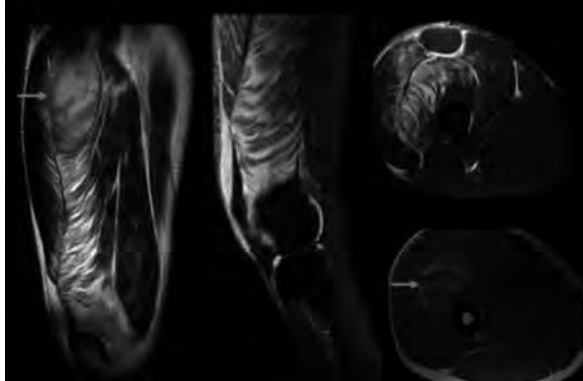
- **Strain (grade I)** affecting to less than 5% of the muscle fibers
- **Partial tear (grade II)**: more extensive injury compromising > 5% of the muscle thickness.
- **Complete tear (grade III)**: affects the entire thickness of the muscle, with muscular discontinuity at the myotendinous junction and with retracted tendon and interposition of hematoma

Partial tear of m. gluteus



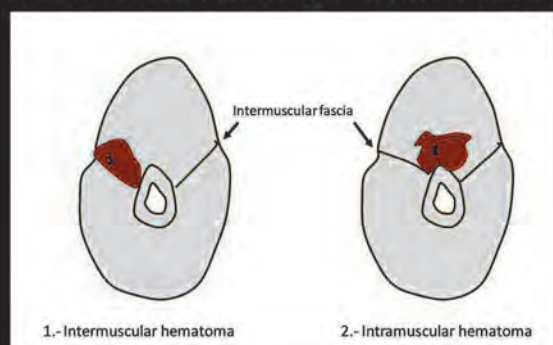
Partial muscle tear

(quadriceps, med & intermed vastus)

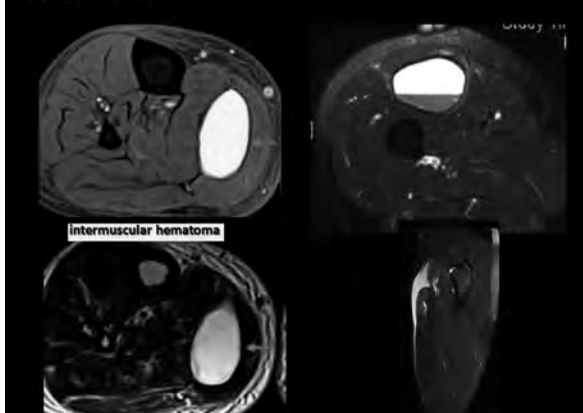


Hematoma

hallmark of muscle rupture secondary to direct contusion or to myotendinous injury



Hematoma



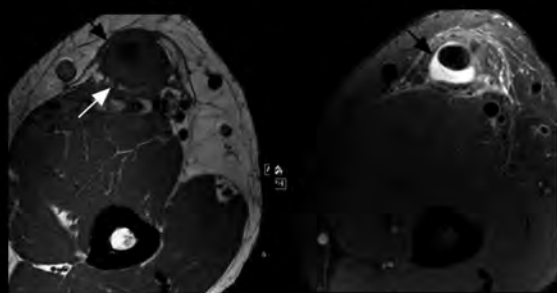
Muscle injuries classification system

	O'Donoghue 1962	Ryan 1969 (initially for quadriceps)	Takebayashi 1995, Peetrons 2002 (Ultrasound-based)	Stoller 2007 (MRI-based)
Grade I	No appreciable tissue tearing, no loss of function or strength, only a low-grade inflammatory response	Tear of a few muscle fibres, fascia remaining intact	No abnormalities or diffuse bleeding with/without focal fibre rupture less than 5% of the muscle involved	MRI-negative=0% structural damage. Hyperintense oedema with or without haemorrhage
Grade II	Tissue damage, strength of the musculotendinous unit reduced, some residual function	Tear of a moderate number of fibres, fascia remaining intact	Partial rupture: focal fibre rupture more than 5% of the muscle involved with/without fascial injury	MRI-positive with tearing up to 50% of the muscle fibres. Possible hyperintense focal defect and partial retraction of muscle fibres
Grade III	Complete tear of musculotendinous unit, complete loss of function	Tear of many fibres with partial tearing of the fascia	Complete muscle rupture with retraction, fascial injury	Muscle rupture=100% structural damage. Complete tearing with or without muscle retraction
Grade IV	X	Complete tear of the muscle and fascia of the muscle-tendon unit	X	X

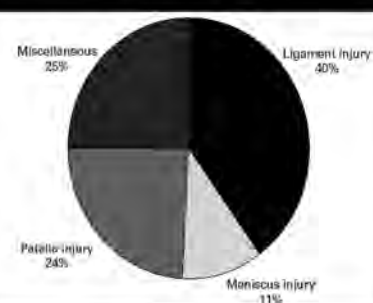
Terminology and classification of muscle injuries in sport:
The Munich consensus statement

Mueller-Wohlfahrt H-W, Haensel L, Mithoefer K, et al.
Br J Sports Med 2013;47:342-350.

Distal biceps tear



Knee traumatic lesions



•Football
•Soccer
•Skiing
•Tennis
•Gymnastics
•Judo
•Handball
•Volleyball
•Basketball

Steve Bollen Br J Sports Med 2000;34:227-228

Multiligament Injuries of the Knee

- Anterior cruciate ligament (ACL): anteromedial & posterolateral bundles relative to tibia
- 86% of resistance to anterior translation of tibia relative to femur
- limits internal rotation of tibia relative to femur, provides secondary restraint to valgus and varus stress aiding medial collateral ligament (MCL) and lateral collateral ligament (LCL)
- Posterior cruciate ligament (PCL): anterolateral and posteromedial bundles relative to femur
- 95% of resistance to posterior translation of the tibia relative to femur

Multiligament Injuries of Knee
Most Common Types of Knee Dislocation
Using the Positional Classification Method
Kennedy classification system (1963)

Mechanism of Injury	Resultant Position of Tibia
Hyperextension	Anterior
Direct blow to anterior tibia	Posterior
Varus/internal rotation	Medial
Valgus/external rotation	Lateral
Valgus and internal rotation	Posterolateral

- External rotation of tibia in coronal plane - (i.e., valgus or abduction rotation)
- Internal rotation in coronal plane - (i.e., varus or adduction rotation)
- External rotation of tibia in axial plane
- Internal rotation of tibia in axial plane

Stuart MJ. Oper Tech Sports Med 2001;9(2):91-95

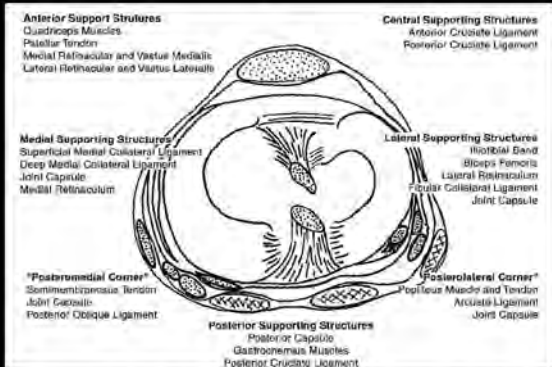
Multiligament Injuries of the Knee

Table 1
Forces Responsible for Knee Injuries and Supporting Structures Responsible for Primary and Secondary Resistance to Those Forces

Force	Primary Resistance	Secondary Resistance
Anterior translation (displaces tibia anteriorly)	ACL	MCL, LCL
Posterior translation (displaces tibia posteriorly)	PCL	None
Varus (medial to lateral)	LCL	ACL, PCL
Valgus (lateral to medial)	MCL	ACL, PCL
Internal rotation (femur fixed)	LCL	ACL, capsule
External rotation (femur fixed)	MCL	PCL, capsule
Hyperextension	PCL	ACL, posterior capsule

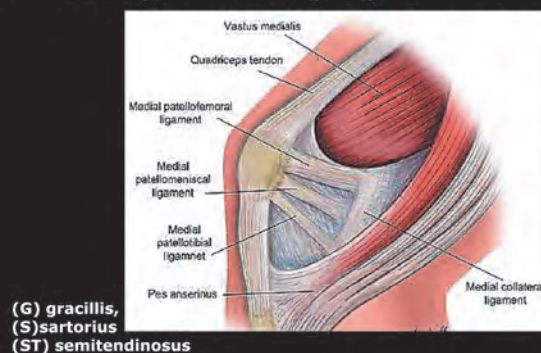
RadioGraphics 2000; 20:S121-S134

Multiligament Injuries of the Knee



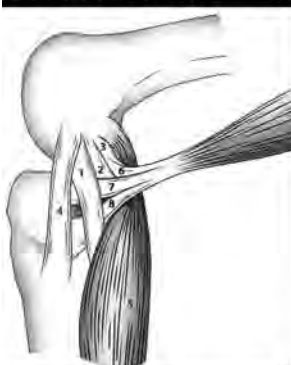
C. W. Hayes et al Radiographics 2000; 20:S121-S134

Multiligament injury of knee



Recondo JA et al (2000) Radiographics 20:S91-S102

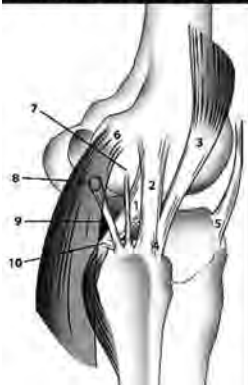
Posteromedial corner structures of knee



- 1 superficial arm of the posterior oblique ligament (POL)
- 2 tibial arm of the POL
- 3 capsular arm of the POL
- 4 medial collateral ligament
- 5 medial head of the gastrocnemius muscle
- 6, 7, and 8 tendinous insertions of the semimembranosus muscle

Semin Musculoskelet Radiol 2011;15:42-58.

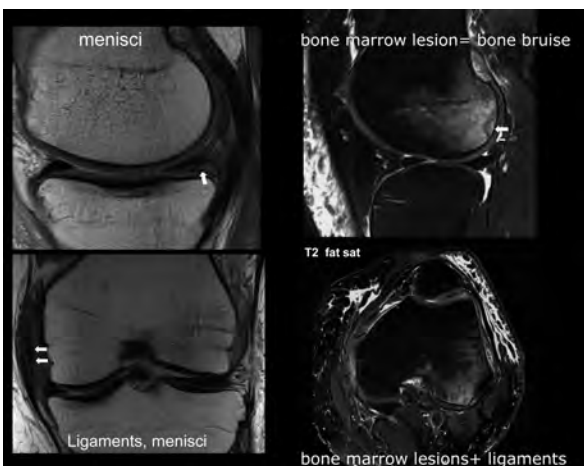
Posterolateral corner structures of the knee



- 1 popliteus tendon
- 2 lateral collateral ligament
- 3 biceps femoris tendon
- 4 conjoint tendon
- 5 iliotibial tract
- 6 lateral head of gastrocnemius muscle
- 7 arcuate ligament
- 8 fabella within lateral head of gastrocnemius tendon
- 9 fabellotibular ligament
- 10 popliteofibular ligament

injury is THE most important
 injury
 Complex anatomy
 Highly infrequent

Semin Musculoskelet Radiol 2011;15:42-58.

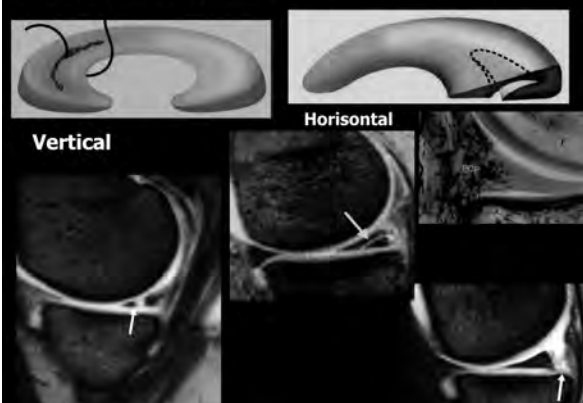


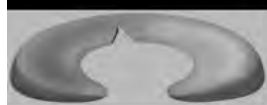
Meniscal lesions



- Abnormal shape
 - Subtle yet highly predictive!
- Abnormal (linear) signal intensity
 - When on 3 consecutive slices visible > 90% arthroscopic +
 - However: reaching to the articular surface

Significant meniscal lesion

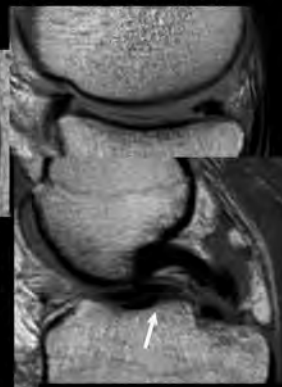
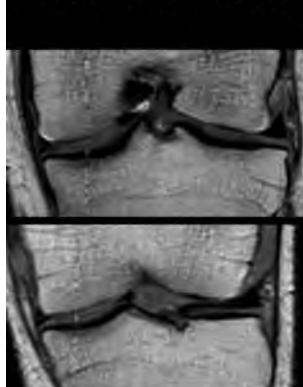


Significant meniscal lesion

Vertical radial



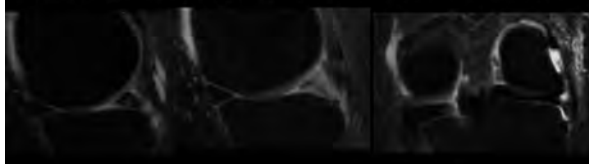
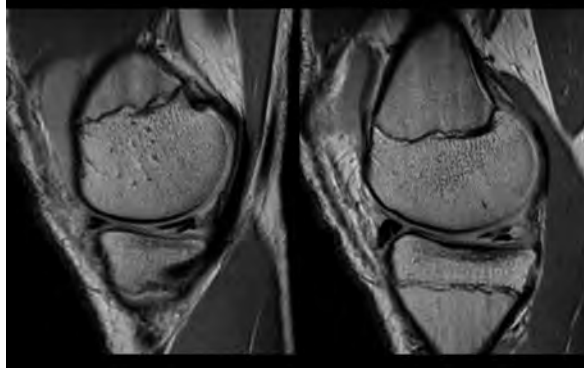
« Bucket -handle»

**Dislocation needs to be addressed**

Double PCL sign

Radial meniscal tear

«invisible meniscus sign» on coronal & sagittal MRI images

**Bucket handle tear****Sports meniscal lesion**

- Frequently posterior horn medial meniscus
- Infrequently anterior lateral meniscus
- Most peripheral tears (in red zone vascularized zone) will heal

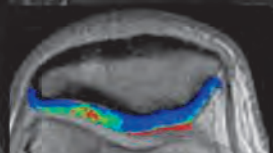
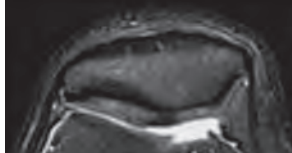
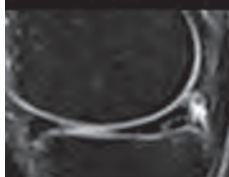
- Shape and signal intensity (watch out for pitfall ant horn lateral meniscus)
- Pathology most frequently posterior horn medial meniscus
- Displacement is most significant item
- Degeneration (age related) : evaluate cartilage
- Bucket handle tears

Indirect arthrography**MR Arthrography**

- High accuracy for the evaluation of meniscal injury
- Invasive
- May be useful for the evaluation of postoperative meniscus

Chondral lesions: MRI !

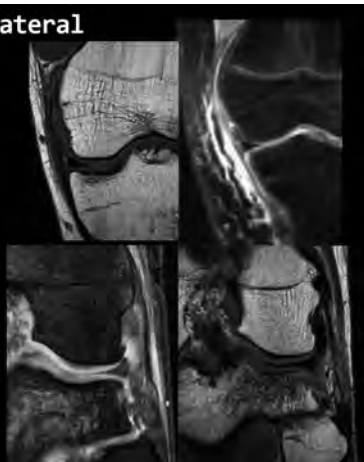
Lesion of meniscus
Lesion of hyaline cartilage

**Intraarticular knee lesions -
haemartrosis & lipohaemartrosis**

Lesions of collateral ligaments

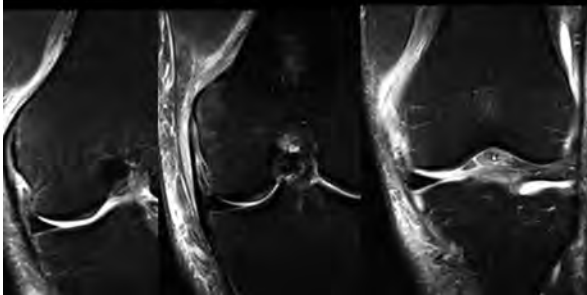
Combination

- Medial meniscus
- Lateral meniscus
- Medial & lateral collateral ligaments

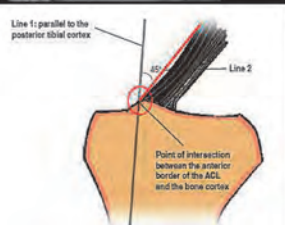
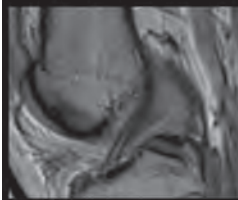


Grading of collateral ligaments lesions

- 1 gr – edema around the ligament
- 2 gr – internal structural changes
- 3 gr – complete rupture



Intraarticular ligaments lesion ACL



Blumstein angle $\leq +9.5^\circ$

ACL full-thickness tear

Direct signs:

- Discontinuity
- Abnormal slope ACL
- Non-visualisation
- Avulsion tibial spine
- Posterior bowing, drooping or dangling of ACL
- High T2 signal with thickening & abnormal morphology ACL



Sanders et al AJSM 2005 p131-148

Indirect signs ACL

Specific for ACL injury

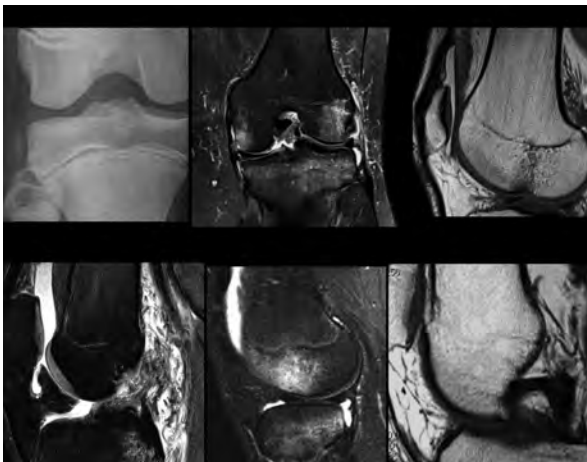
- Pivot shift contusion pattern : mid to posterior lat femoral condyle & post tibial plateau (+ MM tear)
- Deep lateral femoral sulcus sign
- Uncovered posterior horn lateral meniscus
- Second Fracture : cortical avulsion fracture of tibial lateral plateau 75 – 100 % related with ACL lesion
- Deep femoral notch

Associated, but not specific for ACL injury

- Bone bruise – kissing contusion
- Effusion – acute haemarthrosis
- Anterior tibial displacement
- PCL angle

Associated injuries:

- Medial meniscal tear
- Lateral meniscal tear
- Medial / lateral collateral injury



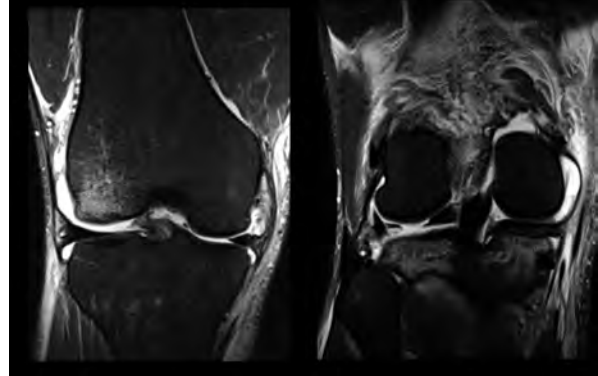
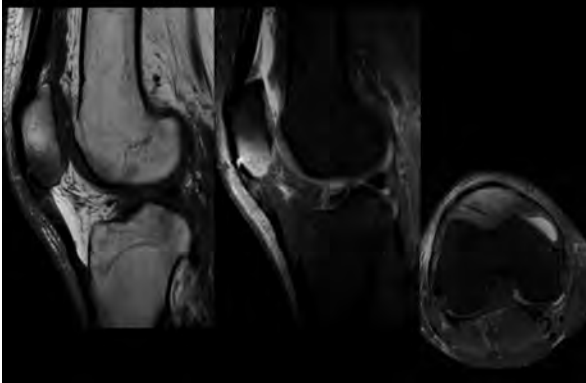
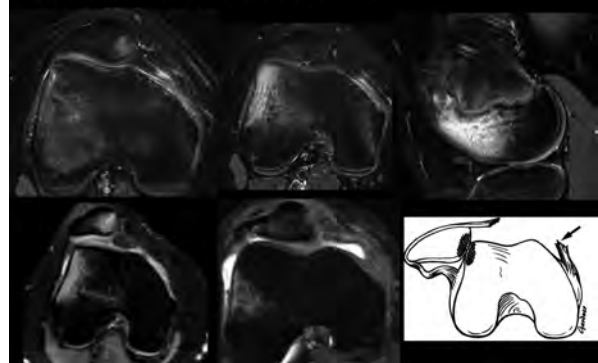
PCL injuries – MRI signs

Direct signs

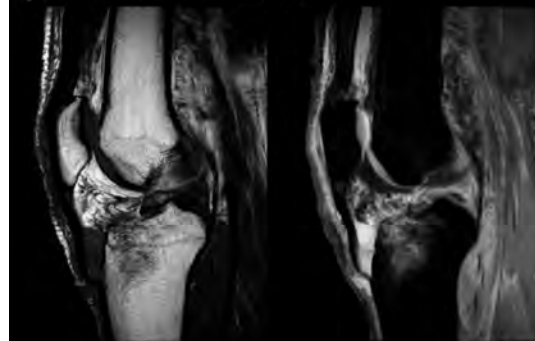
- Incomplete tear or sprain – high T2 signal
- Complete tear – in mid fibres of PCL
- Osseous avulsion fractures at osseous attachment
- complete absence of PCL

Indirect signs

- Bone contusion of anterior aspect of tibia
- Kissing contusion – anterior tibia & femur (ACL+PCL)
- Fibula head avulsion fracture
- Gerdy's tubercle avulsion injury of ITB

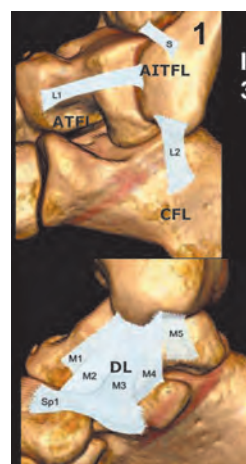
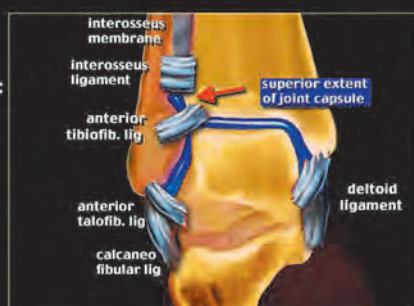
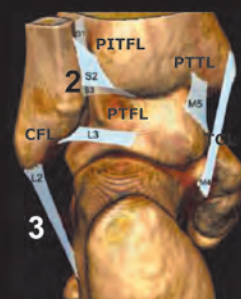
PCL**Multiligament injury of knee****Fracture of lower pole of patella after trauma****Bone bruise – correspond with site of lesion**

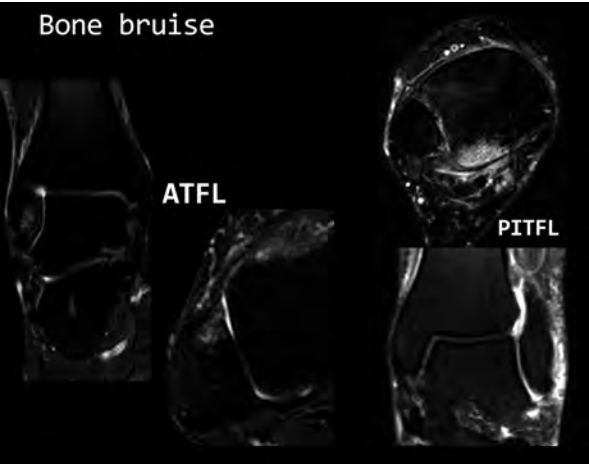
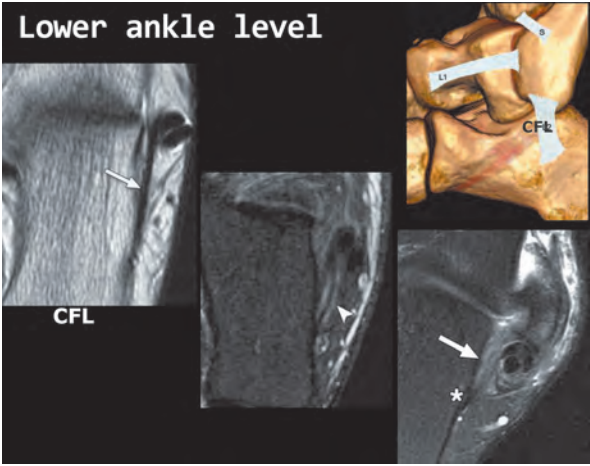
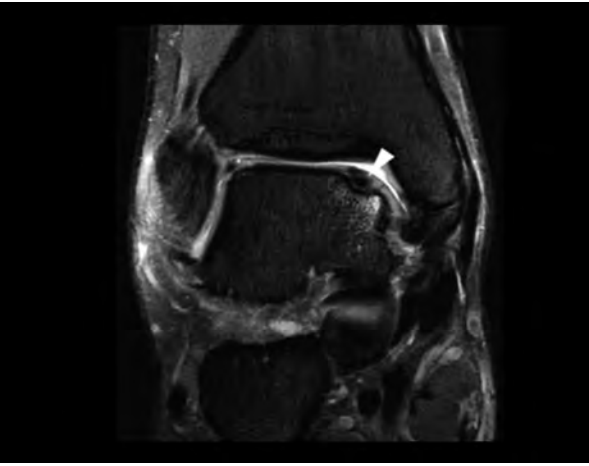
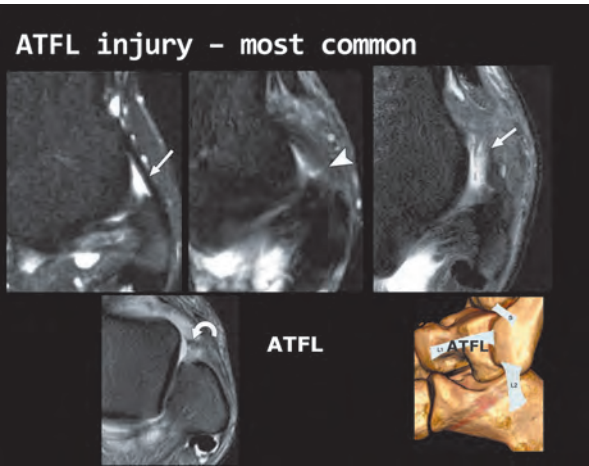
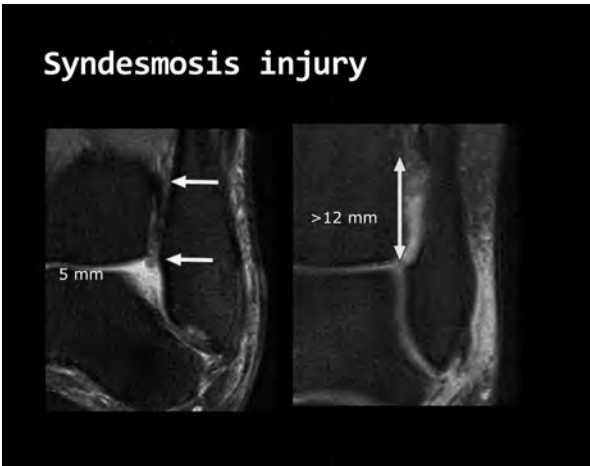
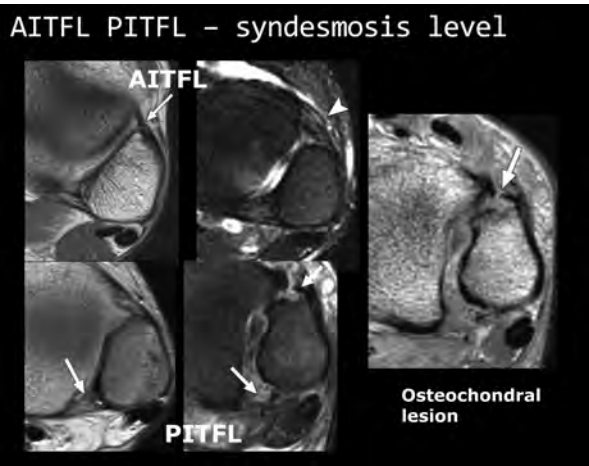
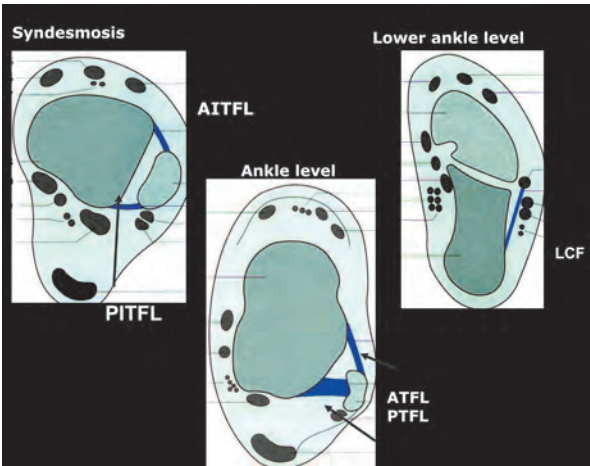
- Edema at insertion site
- Might correspond with MCL lesions

Partial thickness tear of patellar tendon**Injuries in the foot and ankle**

▪ Main forces:

- supination
- pronation
- abduction
- adduction

**Injuries in foot and ankle – 3 levels**

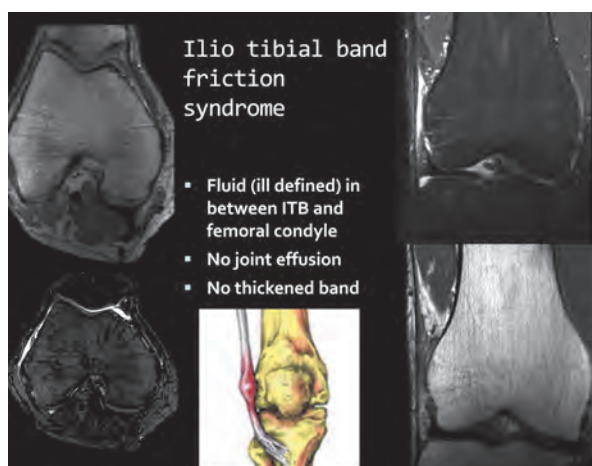


Overuse

- In overuse injury the athlete will not recall having a trauma.
- However, the level of repetitive microtrauma overwhelms the tissue's ability to adapt
- Continuous trauma → continuous injury to tissue
- What: excessive motion, repeated microtrauma, abnormal joint mechanics
- Who: everyone who has increased his physical activity. High performing athlete / slightly overweight middle aged radiologist
- Where: Tendons, enthesis, cartilage, bone. In adolescent apophysis

Overuse knee sport related

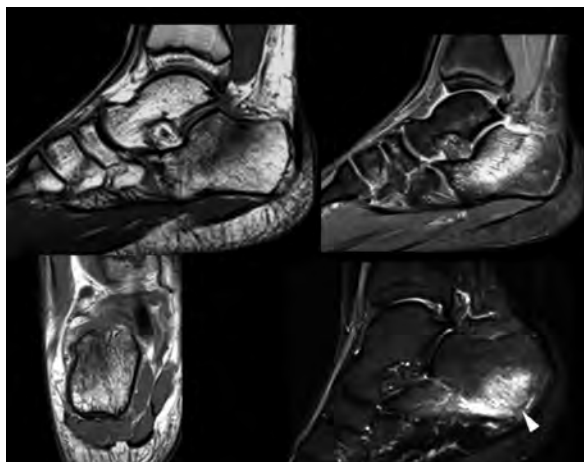
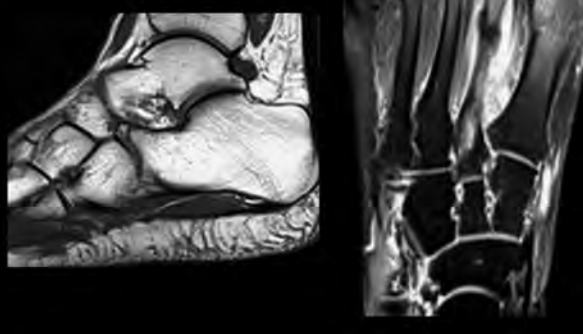
- Breaststroke swimmer's knee: overuse lesion on medial side of the knee with synovitis, pes anserinus bursa?
(Keskinen et al Am J sports med 1980)
- Cyclist's knee: iliotibial band friction syndrome: (Farell et al Knee 2003, Holmes et al Am J Sports Med 1993)
- Runner's knee: iliotibial band friction syndrome
- Jumper's knee: tendinopathy patellar tendon or quadriceps tendon



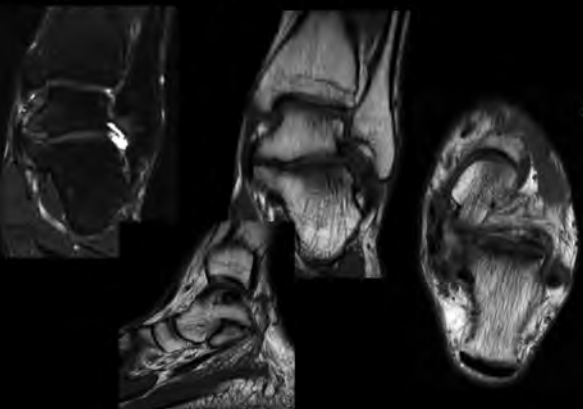
Patella tendinitis



Stress fractures Osteochondral lesions



Talo-calcaneal coalition



- The musculoskeletal radiologist has a pivotal role in the diagnosis, prognostication, and ultimately in the management and rehabilitation of lower limb athletic sports injuries.
- Making the correct diagnosis is essential, but helping clinicians predict time out from competitive activity and contributing to the management and rehabilitation of the athlete are becoming more important challenges

