

## HIP MRI

### SEQUENCES:

Bones:	scout, cor T1, cor PD FS
FAI:	axial T1 (angled)
Capsule/cartilage:	cor PD FS (angled), sag PD FS
Labrum:	cor PD FS (angled), axial T1 FS and PD FS radial sag PD (parallel to neck)+ axial scout (place crosshair) sag PD FS (not as useful)
Muscles/Tendons:	axial T1 FS, cor PD FS, and any T1 without FS

### OSSEOUS STRUCTURES (for hip imaging, axial and coronal are the most important)

**-Acetabulum** (bony rim and labrum absent inferiorly at “acet notch” covered by transverse lig; “acet fossa” is devoid of cartilage and filled w/ fibrofatty tissue & synovium)

-acetabular dysplasia; protusio (when femoral head projects medial to ilioischial line); retroversion (figure of 8; anterior acet is more lateral than post acet)

-post disloc (avulsion of post-acet; labral and chondral injuries +/- entrapment; disruption of iliofemoral lig (ant); hemarthrosis; sciatic nerve injury; risk=AVN)

**-Femur** (lot of red marrow in femur/pelvis which has int signal, higher than muscle; fatty marrow epiphysis & trochanters; marrow conversion: epi→dia→metaphysis)

-small amount of red marrow in subchondral femur head epi is normal; diffuse red marrow seen with anemia or chronic illness; marrow

packing or infiltrative d/o

-femoral neck 115-140deg with respect to femoral shaft

-head/neck (fovea centralis does not have articular cartilage but contains low T1/T2 lig teres & pulvinar aka fibrofatty tissue→lig teres

inserts into transverse lig)

-trochanters (enthesophytes)

### **-Iliac**

**-Sacrum** (insuff fx parallels SI joint & may cross midline if bilateral aka “Honda sign”), Ilium (supracetabular “raised eyebrow” insuff fx)

**-Ischium** (esp ischial tuberosity)

**-Pubic rami and symphysis**

**-SI joints** (true synovial joint ant-inf half w/ thinner cartilage on iliac side where DJD begins first): bilat symm=ank spond & IBD

**-Red marrow** (usually symmetrically involves metaphysis; conversion to yellow from appendicular→axial and epi→dia→metaphysis; small amount of red marrow in subchondral region OK but can mimic AVN; signal > than muscle on T1 o/w think infiltrative marrow ddx=tumor, OM, edema/trauma, marrow-packing d/o)

**-Fracture** (T1 coronal +/- STIR, axial T2)—stress fx=sclerotic T1/T2 w/ T2 edema compressive>tensile neck; fatigue fx= may lack sclerosis)

**-Stress injury of tibia** (gradeI=periosteal edema, gradeII=also endosteal/BM edema on T2, gradeIII=also abnl BM signal on T1, gradeIV=fx line visible)

**-AVN** early=diffuse then focal edema (can mimic TOH)→serpentine low T1 signal surrounding fatty center (ant-sup head) sharp inner line and ill-defined outer margin due to gray edema→double line sign T2 (hi signal granulation tissue paralleling along inside margin of dark sclerotic band)→late=sclerosis/collapse (subchondral fx and epiphyseal collapse); mimic=gray signal subchondral normal red marrow; “ASEPTIC” anemia (sickle-cell), steroids, ethanol, pancreatitis, trauma, idiopathic, CVD, XRT, LCP, Gaucher’s

**-TOH**=preg women 3<sup>rd</sup> tri < middle-aged men 40-50yo M>F 3:1 no trauma, spont res in 6-8mos, hi T2 from head to intertrochanteric region (unilat), no subchondral low T2 signal (<4mm thick and <1.25cm long c/w irreversible AVN), acetabulum uninvolved, may have effusion, MR +ve 48hrs after pain onset; penia on xray within 4wks (ddx=early AVN or insuff fx or osteoid osteoma)

**-Lig teres tear** (normally homogen low T1/T2; post-traumatic partial/complete tear vs degeneration=hypertrophied lig can be assoc w/ CPPD--osseous erosion/irreg of fovea)

**-Inflam arthritis** (septic and aseptiic inflam arthritis appear similar)—thickened enhancing synovium, bone marrow edema, effusion, erosions

**-Septic hip** (effusion + synovitis; synovial thickening and enhancement; BM edema both sides of joint; mono-articular; aspiration fluid PMN>80k is diagnostic criteria)

**-Sickle cell** (OM vs Infarct; cannot differentiate on MR; consider In-WBC + Tc-SC)

**FAI** (pain w/ flexion/internal rot; assoc w/ ant-sup labral tear; bony frag or os acetabulae at sup-lat acet rim; fibrocystic lesion or

synovial herniation pit)

--PINCER=acet overcoverage due to coxa profunda or acetabular protusio resulting in retroversion "crossover" sign of ant acet c/w pincer-type morphology assoc with FAI + anterior-superior labral tear (perpendicular to articular surface) + post-inf acet countercoup chondral injury

--CAM=femoral head-neck offset with anterior-superior (seen best on axial-oblique) vs lateral (seen best on AP or radial sequences) dysplastic/aspherical bump ("pistol grip" deformity); alpha angle>55 on axial-oblique images (prescribed parallel to long axis of femoral neck); head-neck offset <10mm; labral initially spared→then ALAD=acetabulolabral articular disruption (labrum separated from cartilage at chondralabral jct); may have associated anterior-superior cartilage tear (deep / superficial / flap tear) vs delamination (inverted oreo cookie sign with contrast or fluid undermining articular cartilage)

--Herniation pit (always abnl; in-growth of fibrocartilaginous tissue thru cortical defect; aka fibrocystic lesion; ant-sup-lat at head/neck jc; can be uni/bilateral)

--also look for BM edema, subchondral cystic changes, intraosseous ganglion, synovitis (obscuration of normal sulcus btwn sup labrum and capsule may be an early sign), and capsular thickening (hypertrophy of iliofemoral lig)

## **MUSCLES/TENDONS**

Tendonitis/Tendinopathy; partial/full-thickness tear; avulsion; HADD (calcific tendonitis); myotendinous strain; stress injury

-Anterior: flex (quadriceps=rectus femoris + vastus lateralis/intermedius/medialis; sartorius)

-Medial: adduct (GPA=gracilis, pectineus, adductor longus/brevis/magnus) ←GROIN PULL

-Lateral: abduct (tensor fascia lata, gluteus max/med/min)←GR TROCHANTERIC PAIN SYNDROME (glut med/min tendinopathy/tear > avulsion of gr trochanter)

-Posterior: extend (hamstrings= biceps femoris + semimemb + semitend) ←HAMSTRING INJURY tear (usually SM) vs ischial tuberosity avulsion (usually of conjoint tendon of BF/ST)

-External rotators: (piriformis, quadratus femoris, GOGO's=gemellus sup/inf and obturator int/ext) ←PIRIFORMIS SYNDROME (sciatic nerve neuropathy; mimics radiculopathy)—sciatic nerve located ant or may split thru piriformis and exits via greater sciatic notch

### **ORIGIN/INSERTION:**

ASIS→sartorius

AIIS→rectus femoris

Iliac ala→Gluteal muscle origin

Superior pubic ramus→pectineus muscle

Inferior pubic ramus→adductor longus

Pubic symphysis→adductor brevis and gracilis

Ischial ramus→origin of other adductors

Ischial tuberosity→hamstring origin (superolateral=semimembranosus; inferomedial=conjoint tendon of semitendinosus and long head biceps femoris; BF muscle located lateral, SM inbetween, ST medially; BF and ST come together as conjoint tendon); also insertion of sacrotuberous lig; note: adductor magnus inserts along inferior aspect of ischial tuberosity

Gr trochanter→"GOP" Glut med (lateral and superoposterior), Glut min (anterior), Obturator internus, Piriformis insertion, Bursa (post)

Ls trochanter→Iliopsoas insertion

Gluteal tuberosity of prox femur→Glut maximus insertion

Linea aspera (femoral diaphysis)→insertion on many muscles

### **-Muscle strain:**

-strain (edema at myotendinous junction vs less commonly peripheral edema in epimysial strain' commonly involves hamstring, rectus femoris, medial gastroc, and biceps brachii); laceration (knife); contusion (localized edema with associated ST and BM edema); tear (discontinuity); hemorrhage (can mimic mass so give gad on f/u exam); compartment syndrome (edematous muscle compartment with fascial edema)

-GradeI (pain)=microscopic at musculotendinous jct w/ T2 feathery edema w/ preserved morphology; GradeII (pain/weakness)=partial thickness tear w/ discrete T1 bright intramuscular hematoma or fluid collection (tearing of up to <50% of muscle fibers); GradeIII (pain/weakness/loss of fxn)=complete tear "bull's eye" appearance +/- retraction

-Longer the length of muscle involvement, longer it would take to resolve; more edema/fluid means higher grade; complete tendon or myotendinous tear is Grade III; chronic tear associated with thickened tendon and peritendinous or diffuse muscle atrophy.

-Muscle edema ddx=muscle injury (strain/tear); myositis (increased T2 signal; may be subtle if autoimmune; more obvious and more enhancement if infectious); inflammatory myopathy; DOMS; acute/subacute denervation

-Muscle denervation= acute (increased muscle volume, T2 bright, no fatty infiltration, +muscle enhancement), subacute (normal muscle volume, T2 bright, early fatty infiltration, +muscle enhancement), chronic (decreased muscle volume, no longer T2 bright, increased muscle infiltration, no muscle enhancement)

-Fasciitis (inflammation/fluid/edema tracks along deep fascial planes; +/- assoc myositis; +/-abscess/microabscesses)

-Nec Fasciitis (clinical diagnosis; destruction & necrosis of subcutaneous and deep fascial tissues with dull gray appearance of fascial edema; +/-myonecrosis; +/-abscess/microabscesses; look for vascular thrombosis; late=gas gangrene; spreads rapidly; Gad not

necessary but useful to identify abscess but can underestimate extent of necrosis; typeI=polymicrobial 90% vs typeII=flesh-eating 10%)

-Snapping hip (multiple causes including slipping of iliopsoas tendon over iliopectineal eminence w/ hip flexion/extension)

-Athletic pubalgia (rectus abdominus, pectineus, adductor longus, and levator ani insert at pubic symphysis; tear of rectus abdominis leads to compartment syndrome in region of adductor muscle near sup margin of inf pubis; marrow edema in pubic symphysis and nearby portion of pubic rami and adj muscle edema esp adductors along with tendon tears and even hematoma)

-Osteitis pubis (multiparous women; marrow edema and irreg of pubic symphysis w/ fluid within cartilaginous joint ; may have AP or sup-inf joint incongruity)

-Gluteal tear (aka rotator cuff of hip) from greater trochanter which has 4 facets="anterior" (GlutMin), "lateral" (GlutMed—lateral tendons), "posterior" (trochanteric bursa), "superoposterior" (GlutMed—main tendon); partial/complete tear, avulsion of gr trochanter, glut muscle atrophy

-Abnl muscle signal DDX: bursitis, strain/tear (usually at myotendinous jct), DOMS, contusion/hematoma, myositis, acute denervation (<2wks-1year)

-Intramuscular tumors DDX: hemangioma (contains fat, calc, serpiginous vessels), lipoma, myxoma (mimics cyst but enhances), sarcoma (no surrounding edema), mets (has surrounding edema), lymphoma, neurofibroma ("target"), desmoid & MFH(=low T1 and low/int T2), hematoma, myositis ossificans

## LABRUM/CARTILAGE (*dedicated hip arthrogram*)

### **Labrum**

-post-sup labrum is thicker; labrum usually triangular but may be non-triangular (rounded/flat) in older pts

->90% are anterior or antsup tears (there are no normal variants here!); clockface on sag plane (ant is 3'oclock)

-base vs periphery of labrum

-Resnick classification: longitudinal vertical, longitudinal horiz, radial, complex, labral detachment, acetabulolabral articular destruction (ALAD)

-Others use: degeneration (common>50yo) vs tear (linear/heterogenous signal; deformed/distorted contour) vs detached (partial/complete +/-displacement; contrast interposed at acetabular-labral jct or interface)

### **pitfalls**:

-normal labral variants more common in lower quadrant; no normal variant within ant to sup labrum

-*post-inf sublabral sulcus* on axial

-*perilabral recess* btwn labrum and capsule (small ant and post; larger superiorly)

-*ant-inf sublabral sulcus* (linear-cleft, only partial separation, no perilabral abnl)

-*labro-ligamentous sulcus/recess* btwn labrum and transverse lig anteriorly and posteriorly on cor/sag; anterior labrum pitfall is adj iliopsoas tendon on axial

-*cartilage undercutting*

-Paralabral/para-articular cyst—may be intra-osseous subchondral (within acetabulum)

### **Capsule**

-Stellate crease or supra-acetabular fossa (focal notch in superior acet 12'oclock devoid of cartilage w/o BM edema in young pts; may contain plica or fibrous cord)

-capsule inserts directly at base of labrum anteriorly and posteriorly with a small "perilabral recess"; larger "perilabral recess" seen superiorly

-capsule inserts anteriorly along intertrochanteric line and posteriorly halfway down femoral neck

-capsule reinforced by 3 *longitudinal capsular lig*s: ANT: Iliofemoral=strongest (Y-shaped=medial and lateral bands) + Pubofemoral (hiatus btwn iliofem and pubofem allow comm. w/ iliopsoas bursa in 15%), POST: Ischiofemoral (sup and inf bands)

-circularly oriented fibers known *Zona Orbicularis* encircles the capsule at base of femoral neck (forms a collar)

**Cartilage** ("acet fossa" not covered with cartilage): thinning, fissuring, delamination, partial/full thickness defect, chondral flap seen w/ full-thickness tears; PINCER=assoc w/ countercoup post-inf cartilage degen; CAM=assoc w/ ant-sup cartilage degen

## MISCELLANEOUS

### **Nerve**

-Sciatic nerve=tibial nerve+common peroneal nerve (immed post to post column of acet and lat to ischial tuberosity hamstring insertion; ant to piriformis thru greater sciatic foramen; located btwn quadratus femoris muscle ant and glut max post; normal intermediate stippled signal surrounded by fat; compressive neuropathy or fibrolipomatous hamartoma)

-Piriformis syndrome (piriformis muscle hypertrophy vs inflammation vs anatomic variation leads to compression on sciatic nerve; seen as abnl signal within piriformis muscle; 85% sciatic nerve anterior to piriformis muscle; 12% TN and CPN are split by piriformis with CPN thru muscle; 3% CPN posterior to piriformis with TN thru muscle; 1% sciatic nerve thru muscle)

-Femoral nerve (inguinal canal; etiology include inguinal hernia, iliopsoas bursitis, psoas abscess, aneurysm, etc)

-Obturator nerve (obturator canal; etiology include obturator hernia, osteitis pubis, paralabral cyst)

-Lateral femoral cutaneous nerve (L2/L3; entrapment="meralgia perasthetica" pain/burning/numbness prox lateral thigh; etiology=neuroma vs compression at ASIS near attachment of inguinal ligament overlying iliacus muscle)

**Bursa** (intra-bursal steroid injection)

-iliopsoas bursitis=largest bursa in body; 15% comm. w/ joint; distended in OA/RA/infx; anterior to hip & med to iliopsoas tendon (more lat than paralabral cyst); "hourglass" appearance on coronal; adj to fem A/N/V; may be painful/palpable (mimics mass; gad shows peripheral enhancement)

-greater trochanteric bursitis (mimics gluteal tear in pts w/ lateral hip pain)=3 bursa ("trochanteric" bursa along posterior facet and GluMed & VasLat; "subgluteal medius" bursa btwn GlutMed and lateral facet; "subgluteus minimus" and anterior facet)-- bursa fluid, reactive edema of gr trochanter, and adjacent inflamm changes (survey overlying IT band/tensor fascia lata to r/o "trochanteric friction syndrome")

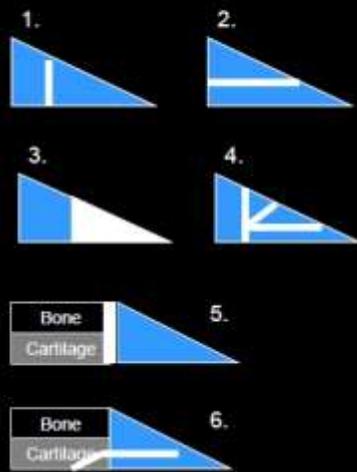
-Morel Lavallee (closed degloving injury; sudden violent stress shear; subq hemolympathic mass along anterolat prox thigh; capsulated)

-PVNS (monoarticular; synovial proliferation w/ hemosiderin tells it from synovial chondromatosis or amyloidosis; pressure erosions)

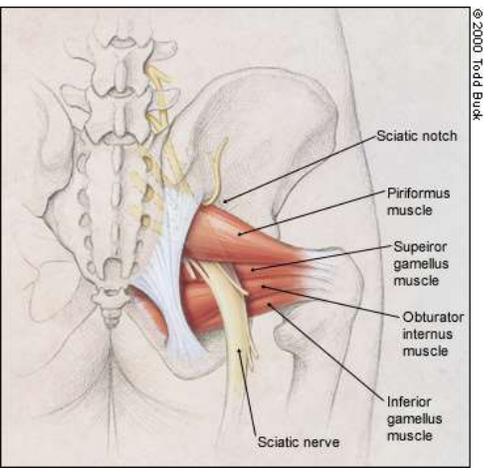
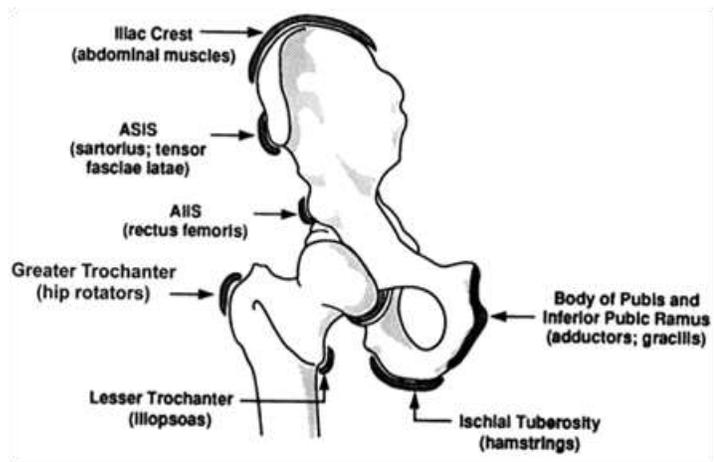
-Myositis ossificans (rim=low signal calc; center=high signal fatty marrow)

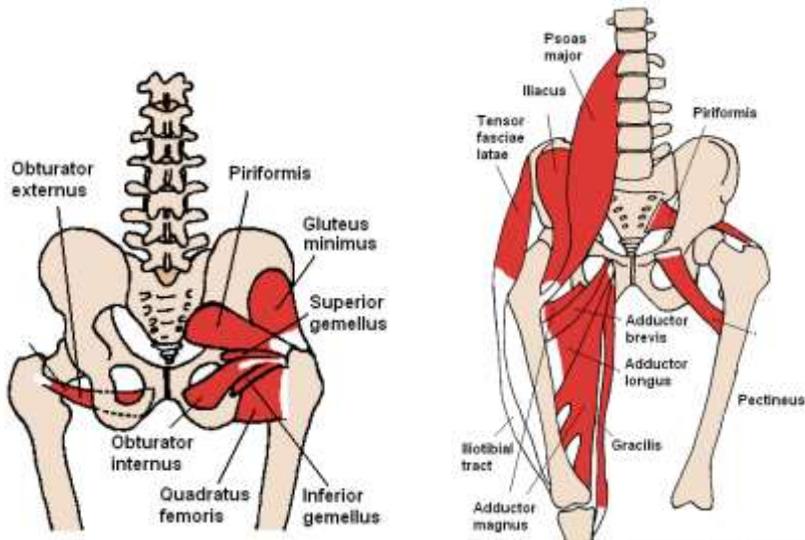
## Resnick's MR Classification of Labral Tears

- Use sagittal plane for location of tear
- Coronal plane (cross reference to other planes) for type of tear
- **Types:**
  1. Longitudinal vertical
  2. Longitudinal horizontal
  3. Radial
  4. Complex
  5. Labral detachment
    - From bone or articular cartilage
  6. Acetabulolabral articular destruction (ALAD)
    - From bone or articular cartilage

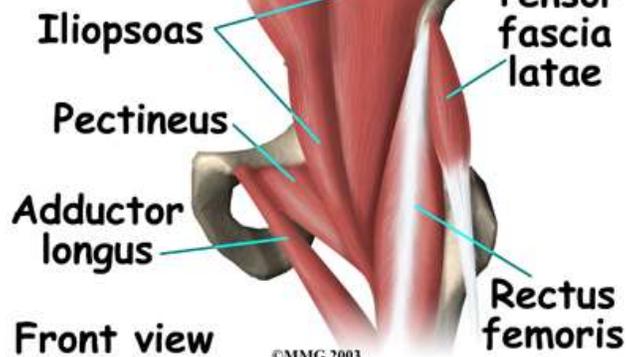


Resnick D. IDJ Advanced Intensive MR Imaging Course Feb 2009

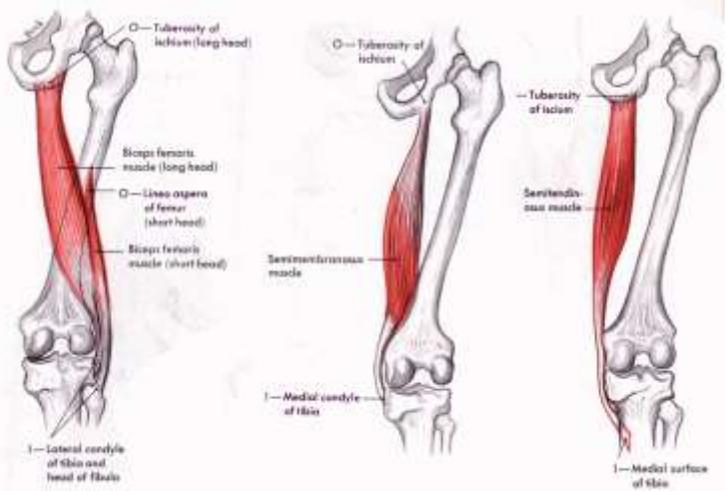




## Hip Muscles



©MMG 2003



Hamstring group of thigh muscles: Sciop femoris, semitendinosus, and semimembranosus.

## Thigh Muscles — Adductors





Facets:

AF=anterior facet

LF=lateral facet

PF=posterior facet

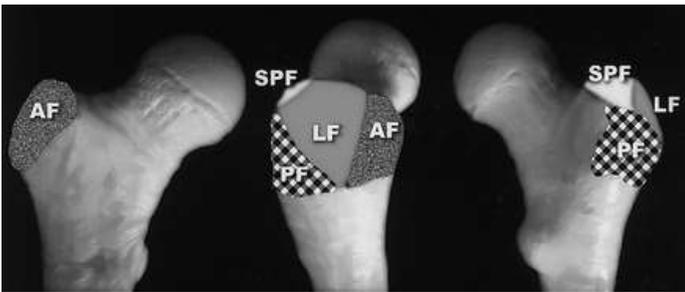
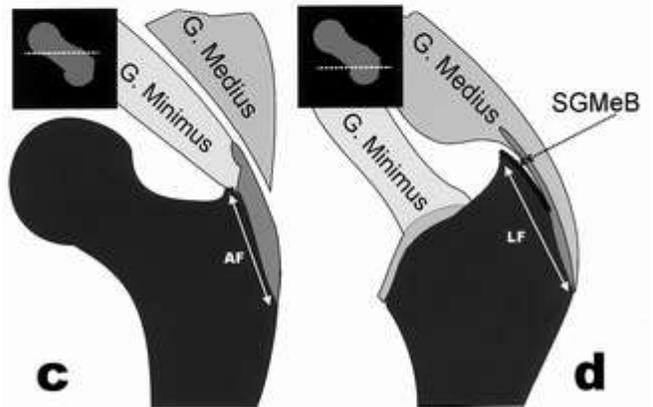
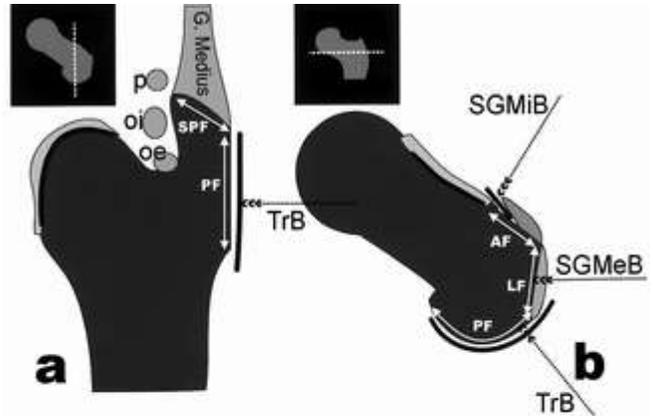
SPF=superoposterior facet

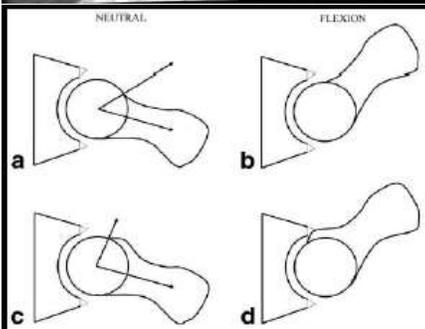
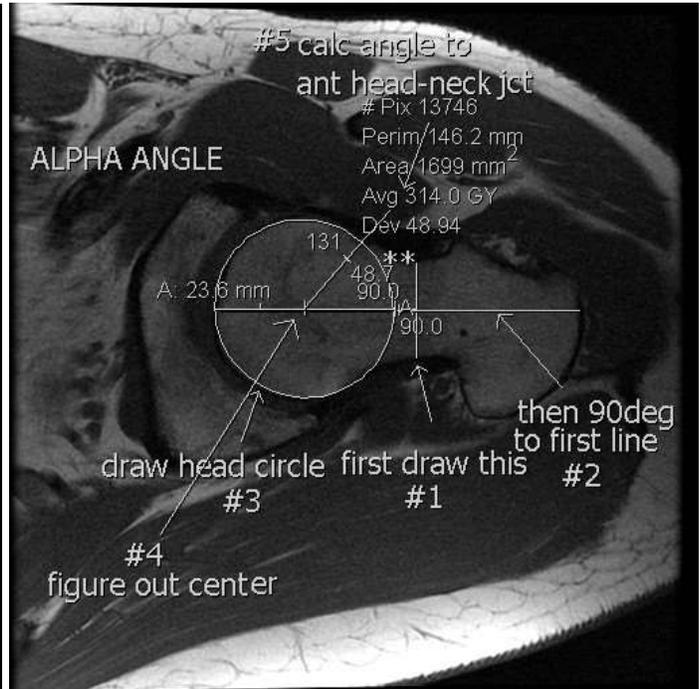
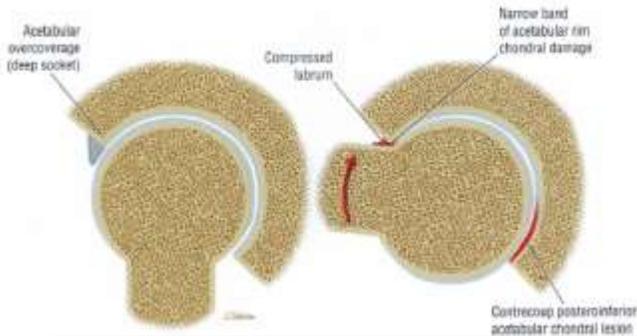
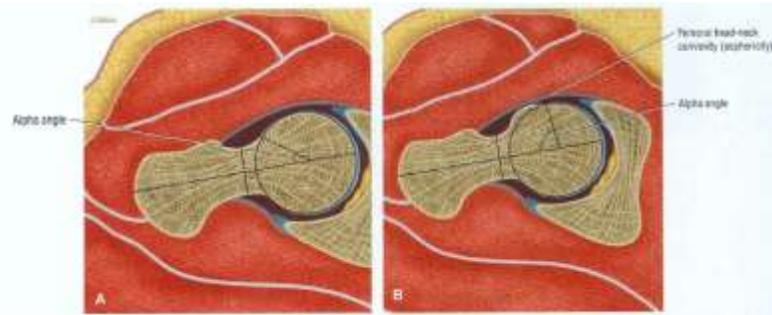
Bursa:

TrB=trochanteric bursa

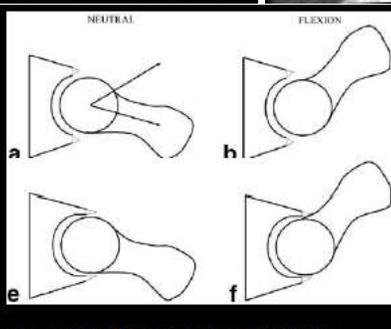
SGMiB=subgluteus minimus bursa

SGMeB=subgluteus medius bursa





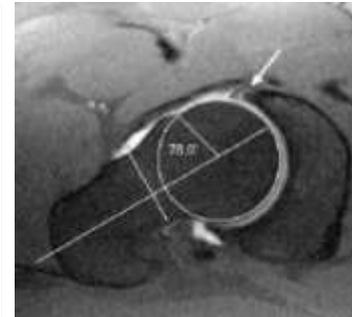
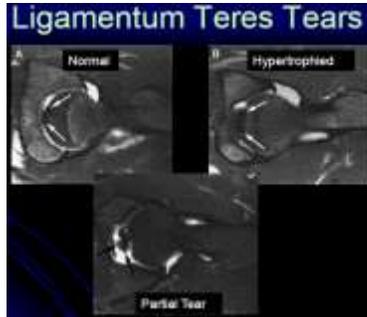
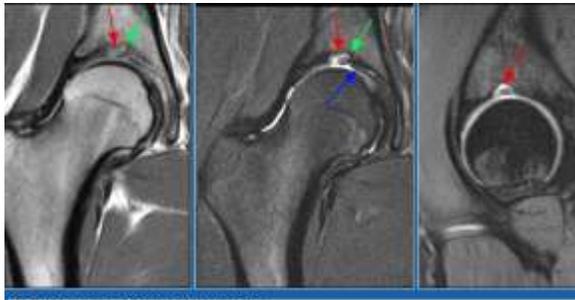
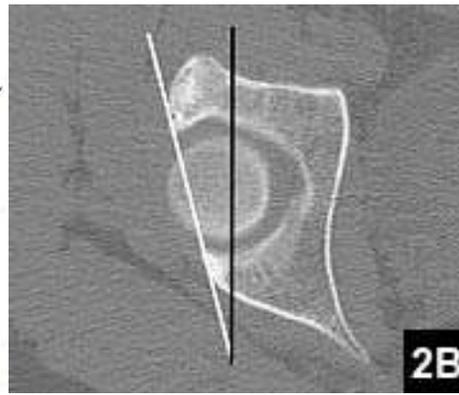
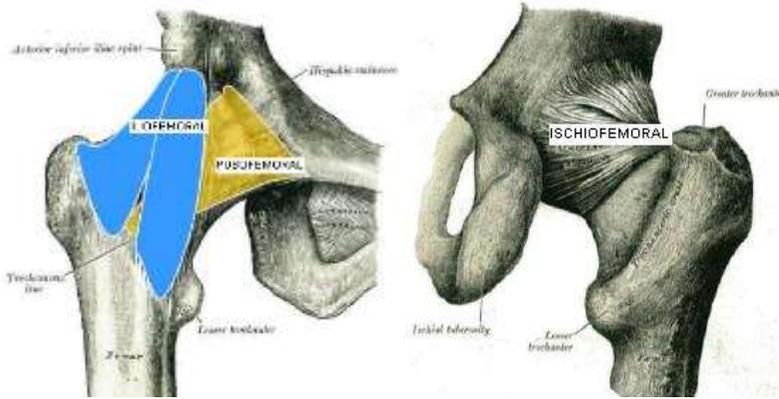
Normal (a/b): Labrum clears with flexion  
Cam type (c/d): Femoral head/neck offset impinging on acetabular labrum



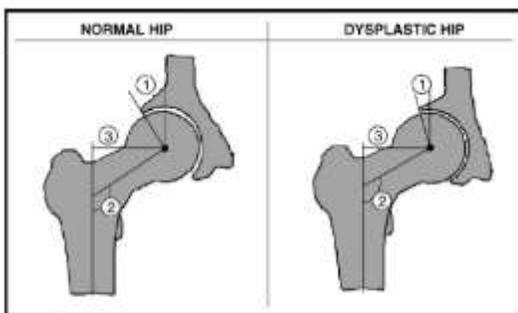
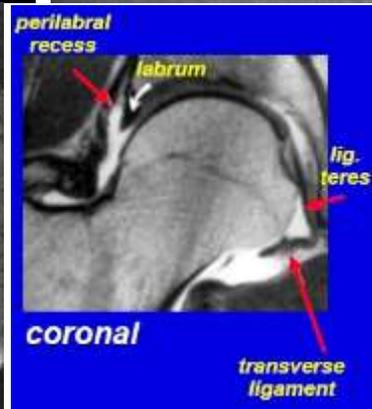
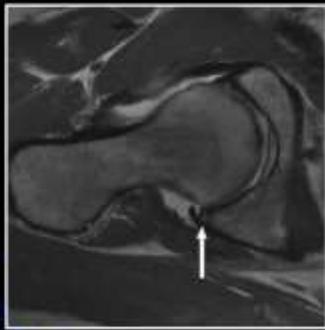
Normal (a/b): Labrum clears with flexion  
Pincer type (e/f): Over-acetabular coverage of femoral head. Abnormal linear contact on acetabular labrum on flexion

### Acetabular Retroversion

Anterior acetabular rim is more lateral and crosses over posterior acetabular rim. "Figure of 8" or crossover sign

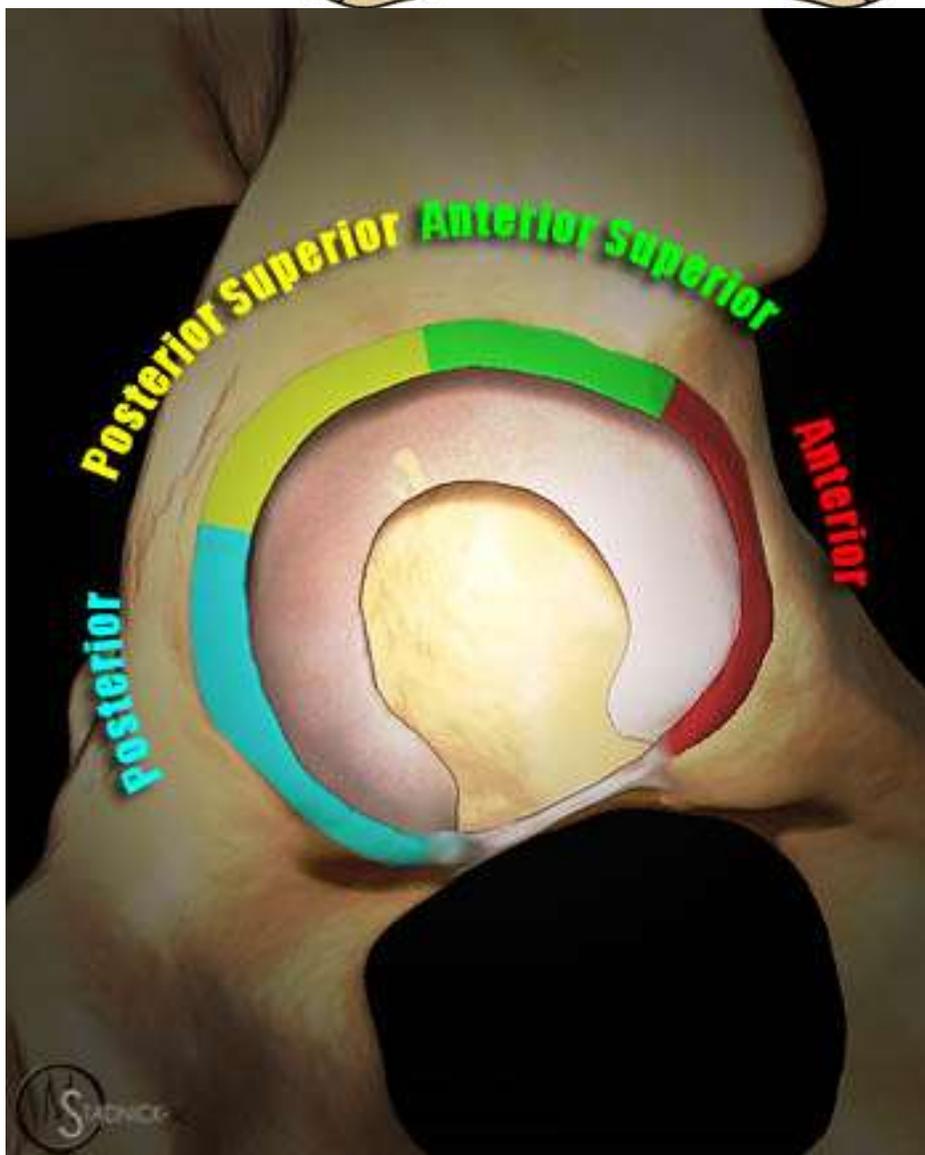
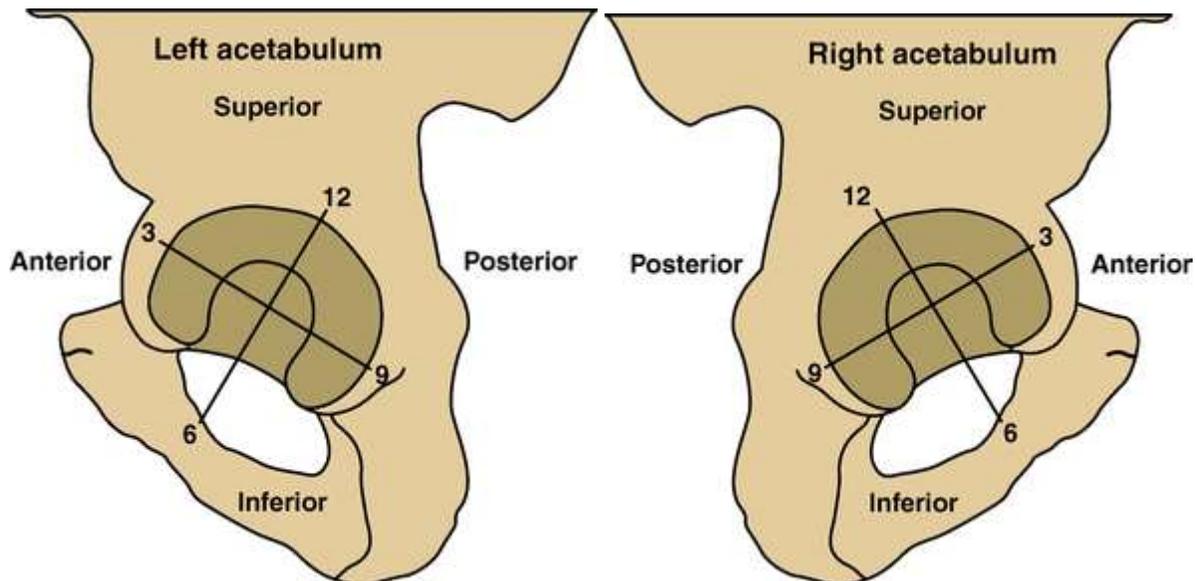


### Posteroinferior Sublabral Sulcus<sup>39</sup>



**Figure 3.** Frontal views of a normal hip (left) and a dysplastic hip (right). (1) Center-edge angle or angle of Wiberg. Normally 30° to 40°, this angle represents the degree of femoral head coverage in the frontal plane. An angle of less than 30° is a characteristic sign of hip dysplasia. (2) Angle of inclination. This angle, between the femoral neck and the shaft of the femur, is normally 125°. In hips with dysplasia, it is commonly increased but also may be decreased.<sup>39</sup> (3) Head offset. This offset represents the perpendicular distance between the femoral head and the shaft. This distance often is decreased with dysplasia.<sup>40</sup>





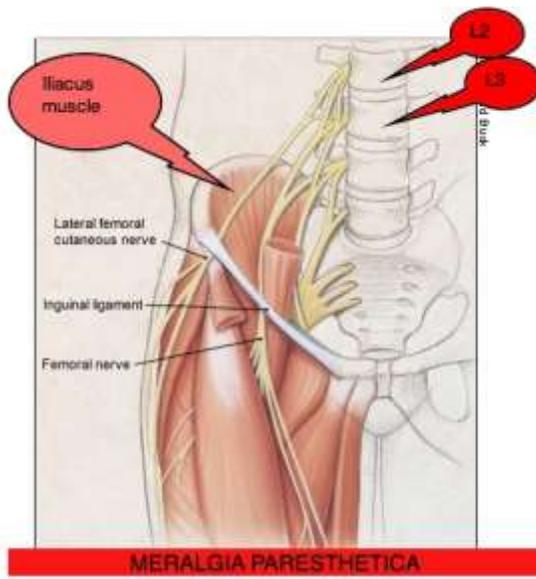
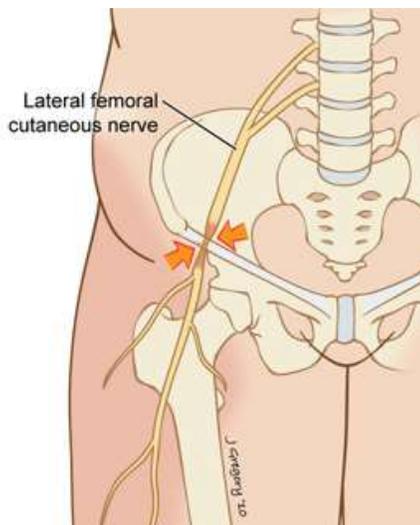
# AVASCULAR NECROSIS OF THE HIP STAGING

## FICAT classification

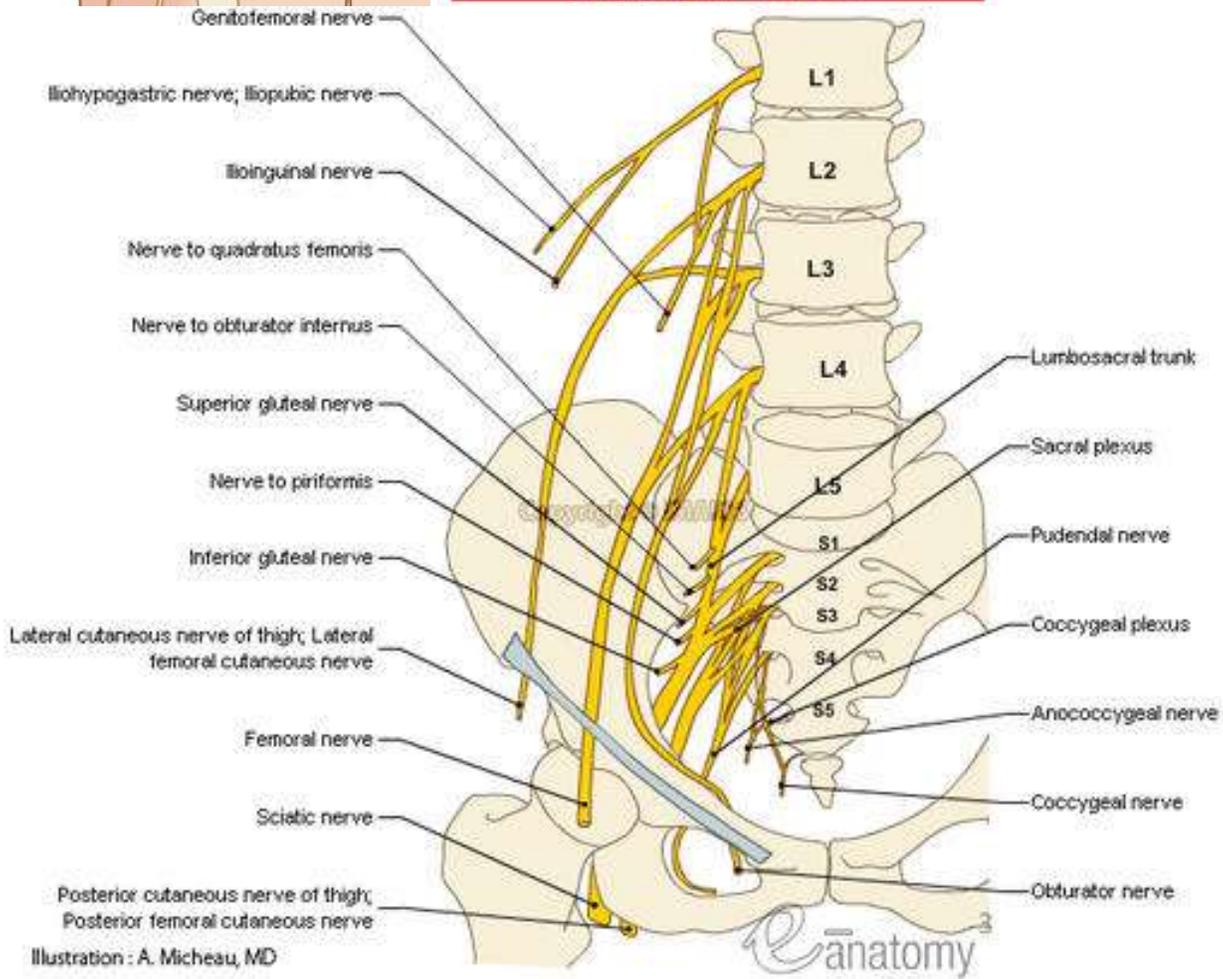
Stage	Xray features	MRI features	Clinical symptoms
0	Normal	Normal or some oedema	nil
1	Normal or minor osteopaenia	Oedema	nil or some pain
2	Mixed osteopaenic &/or sclerosis	Geographic defect	Pain and stiffness
3	Crescent sign &/or cortical collapse	same as Xray	Pain and stiffness +/- radiation to knee
4	Stage 3 + joint space narrowing	same as Xray	Pain and limp

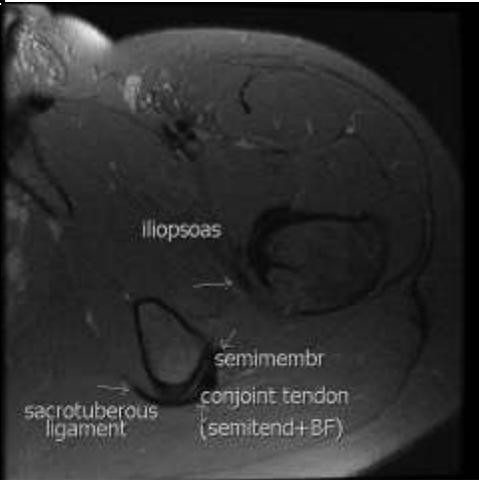
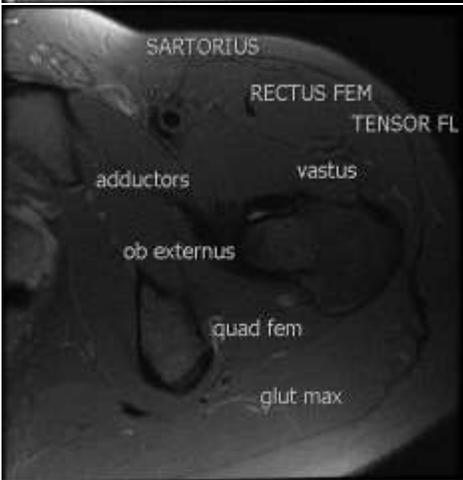
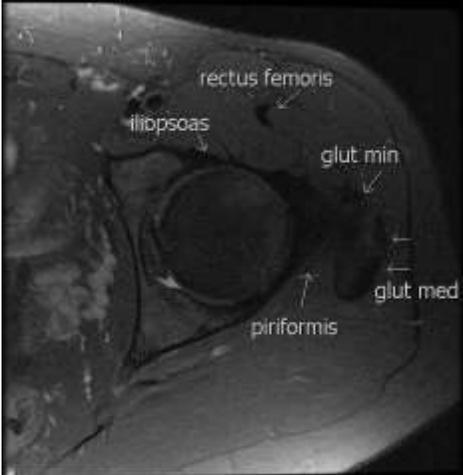
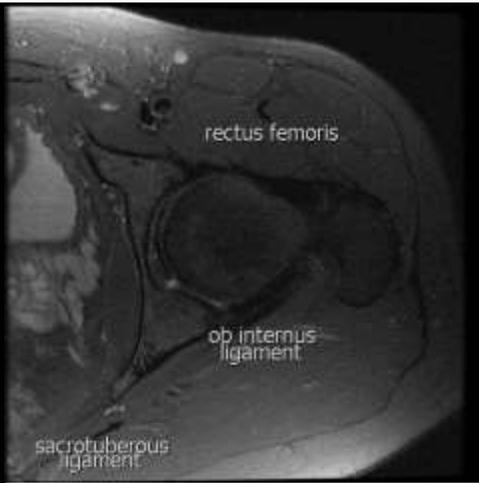
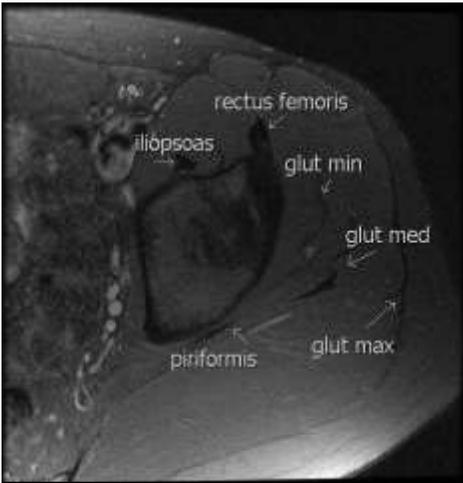
**Table 1 Distinguishing Features of Cam- and Pincer-Type FAI**

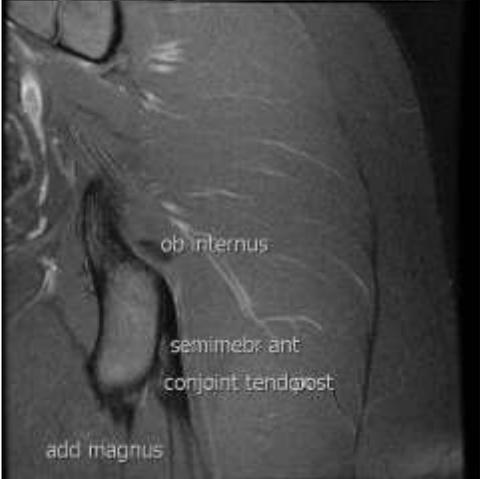
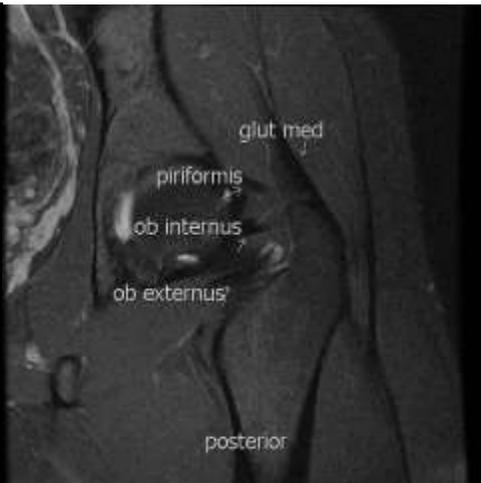
	Cam-Type Impingement	Pincer-Type Impingement
Demographics	Physically active younger males > females	Middle-age women
Primary anatomic abnormality	Asymmetric femoral head contour at head-neck junction and reduced depth of femoral waist	Focal or generalized acetabular overcoverage
Osseous findings	Femoral head-neck junction bump/"pistol grip" deformity; increased alpha angle (>55°); decreased femoral head-neck offset (<10 mm), synovial herniation pit.	Anterior acetabular "Cross over" sign, coxa profunda, ischial spine sign, center edge angle >39°, synovial herniation pit, os acetabulae, double-rim acetabulum/labral calcification.
Labral findings	Labrum initially spared; labrum separated from cartilage at chondrolabral junction. Tip of the labrum usually spared.	Tears are usually perpendicular to articular surface. Tip of the labrum usually spared.
Cartilage findings	Superficial and deep defects, flap tears, and delamination. Focal and usually at anterosuperior region.	Damage in narrow band at the periphery of acetabular rim. Larger area of posterior cartilage damage (contre coup mechanism).



**MERALGIA PARESTHETICA**









Anterior



Vastus lateralis  
Rectus femoris  
Vastus medialis  
Sartorius  
Vastus intermedius

Lateral

Iliotibial tract

Femur

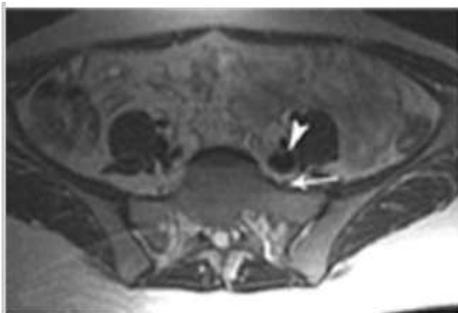
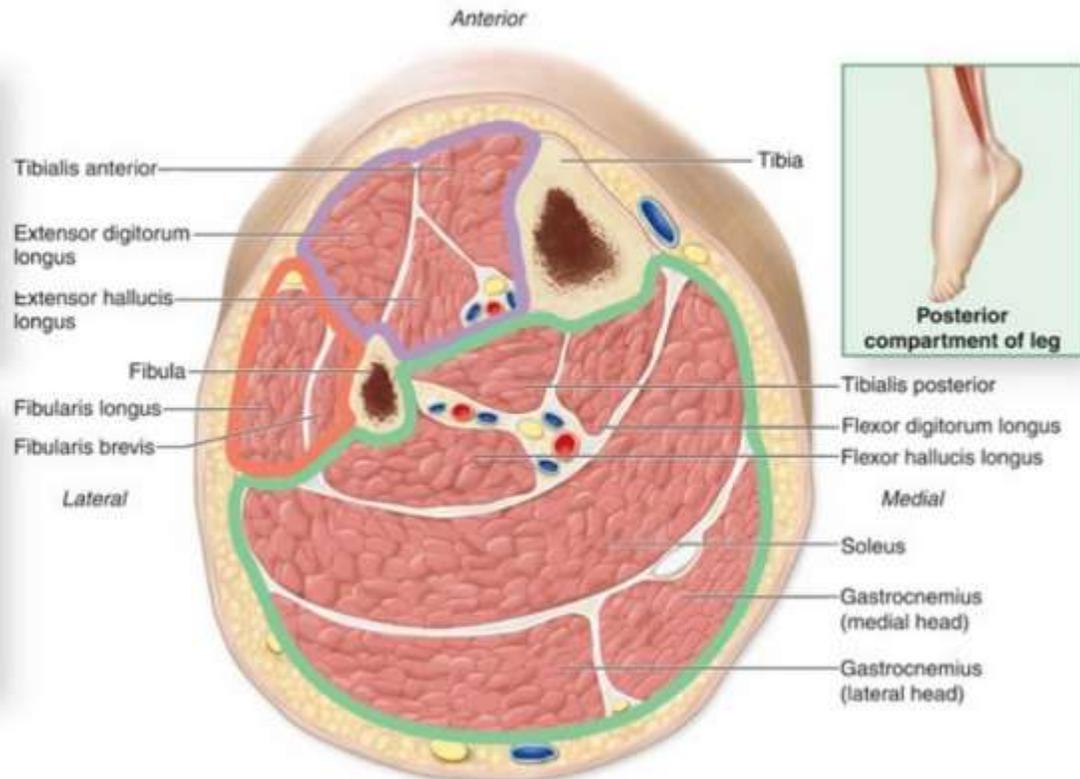
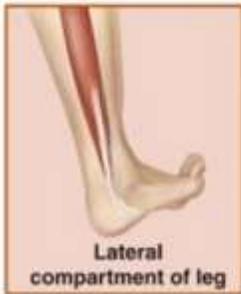
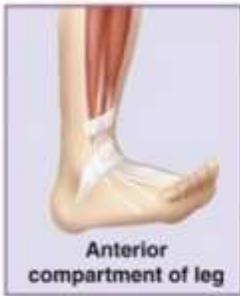
Medial

Adductor longus  
Adductor brevis  
Gracilis  
Adductor magnus



Biceps femoris, short head  
Biceps femoris, long head  
Semitendinosus  
Semimembranosus

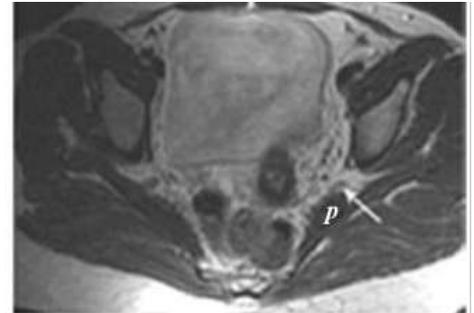
Posterior



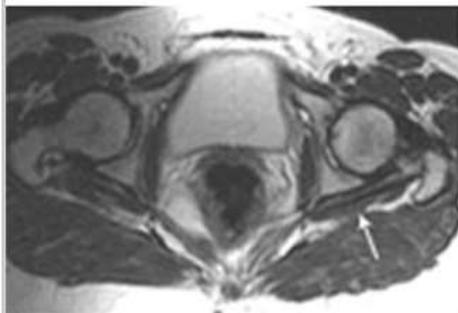
(a)



(b)



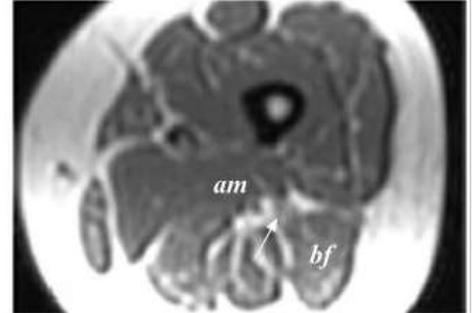
(c)



(d)



(e)



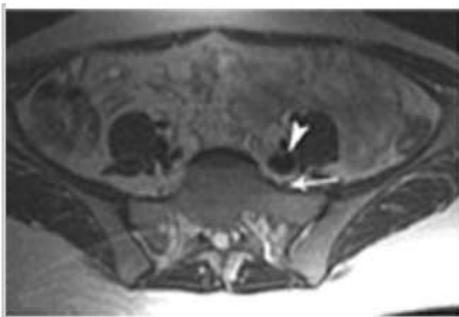
(f)

## Causes of extraspinal sciatic neuropathy

Traumatic causes	Intramuscular injection, abdominal surgical procedures, fracture, haematoma
Infective causes	Abscess ( <i>e.g.</i> psoas abscess, tubo-ovarian abscess and pelvic abscess)
Inflammatory causes	Sacroiliitis
Tumoral causes	
Primary tumours of the sciatic nerve	Schwannoma, neurofibromatosis, neurolymphomatosis and malignant neurofibrosarcoma
Tumours causing compression or invasion of the sciatic nerve	Intra-abdominal or intrapelvic benign or malignant masses, primary (benign or malign) or secondary tumours originating from neighbouring soft tissues and osseous structures along the course of the sciatic nerve and lymphoma
Tumours causing infiltration of the sciatic nerve	Endoneural metastasis and lymphoma
Vascular causes	Aneurysma, arteriovenous malformation and arteriovenous fistulae
Other causes	Endometriosis, leiomyoma, adenomyosis, retroverted uterus, endosalpingitis, haematocolpos, piriformis syndrome, pregnancy, radiotherapy, osteoarthritis

## Causes of extraspinal sciatic neuropathy

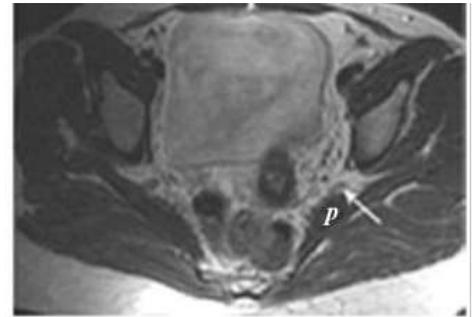
<b>Traumatic causes</b>	Intramuscular injection, abdominal surgical procedures, fracture, haematoma
<b>Infective causes</b>	Abscess ( <i>e.g.</i> psoas abscess, tubo-ovarian abscess and pelvic abscess)
<b>Inflammatory causes</b>	Sacroiliitis
<b>Tumoral causes</b>	
<b>Primary tumours of the sciatic nerve</b>	Schwannoma, neurofibromatosis, neurolymphomatosis and malignant neurofibrosarcoma
<b>Tumours causing compression or invasion of the sciatic nerve</b>	Intra-abdominal or intrapelvic benign or malignant masses, primary (benign or malign) or secondary tumours originating from neighbouring soft tissues and osseous structures along the course of the sciatic nerve and lymphoma
<b>Tumours causing infiltration of the sciatic nerve</b>	Endoneural metastasis and lymphoma
<b>Vascular causes</b>	Aneurysma, arteriovenous malformation and arteriovenous fistulae
<b>Other causes</b>	Endometriosis, leiomyoma, adenomyosis, retroverted uterus, endosalpingitis, haematocolpos, piriformis syndrome, pregnancy, radiotherapy, osteoarthritis



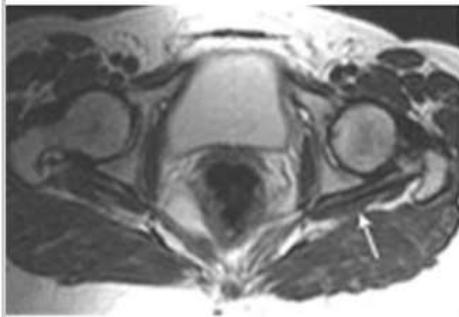
(a)



(b)



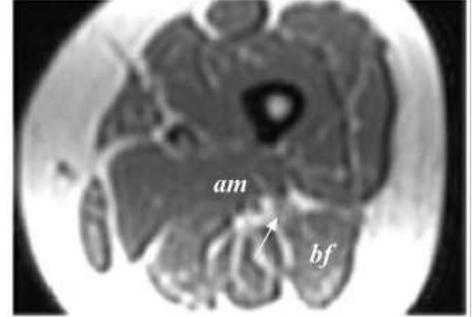
(c)



(d)



(e)



(f)