

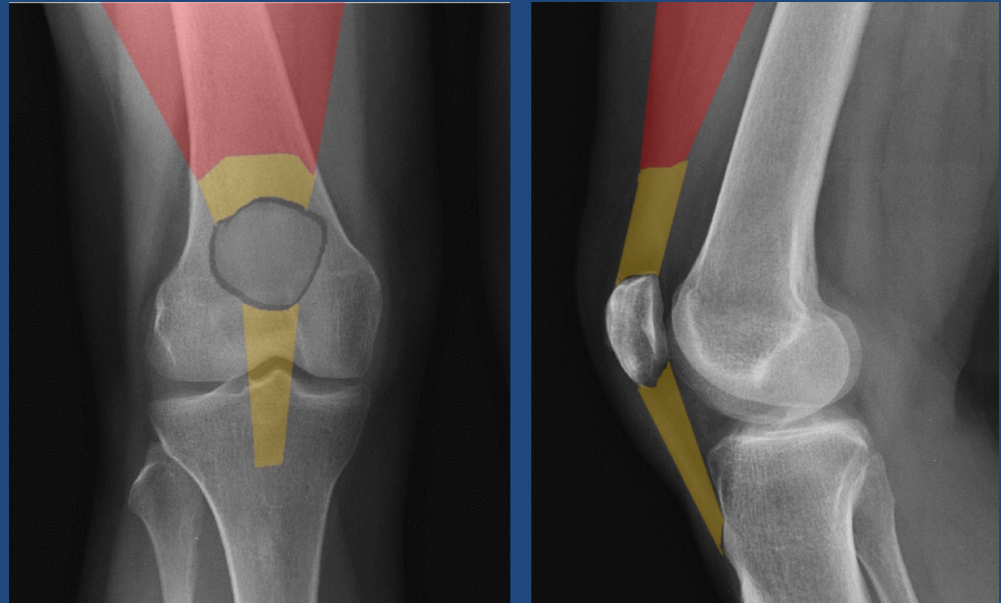
Pr Thomas NERI

MD, PhD



BONE FRACTURES & AVULSION

EXTENSOR SYSTEM RUPTURES SETTING

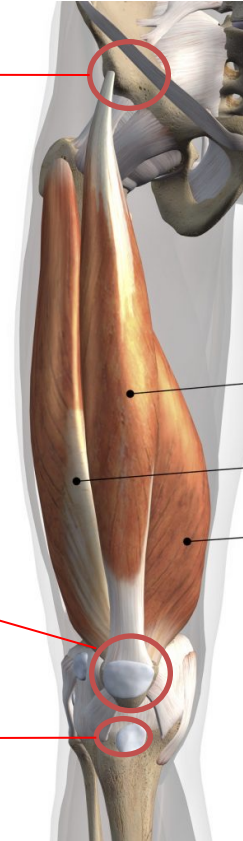


Anterior inferior iliac spine

Patella

- Bone
- Proximal avulsion (QT)
- Distal avulsion (PT)

Tibial tuberosity

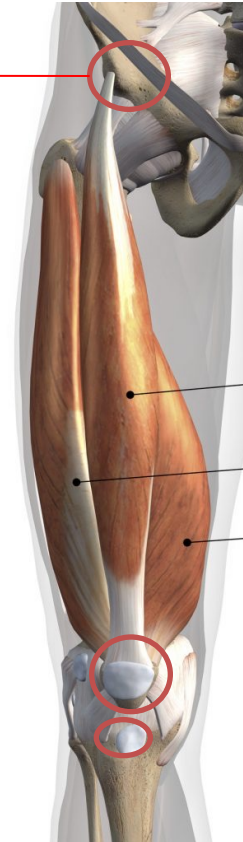


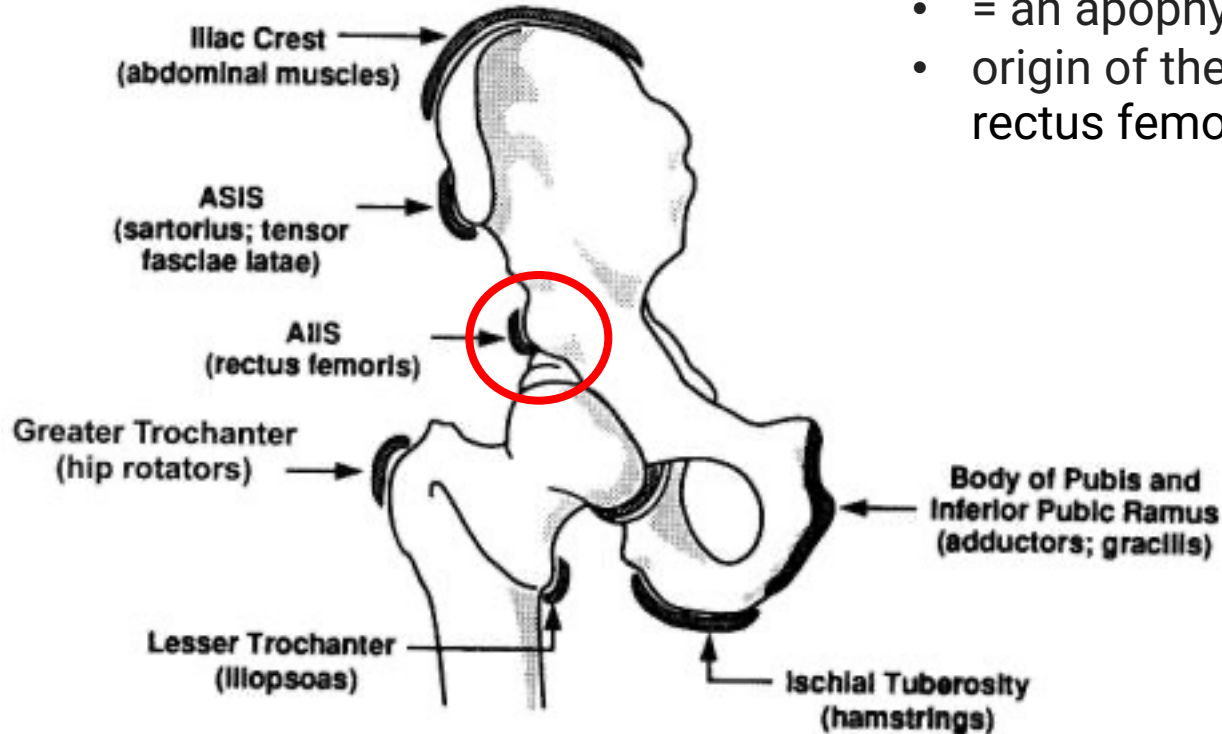
Anterior inferior iliac spine

Patella

- Bone
- Proximal avulsion (QT)
- Distal avulsion (PT)

Tibial tuberosity





- = an apophyseal avulsion injury
- origin of the direct head of the rectus femoris



DEMOGRAPHICS

- most often in **adolescents** between the ages 14-17
- males more often than females
- occurs most often in **sports involving kicking**

ETIOLOGY

- typically occurs due to **eccentric contraction of the rectus femoris** as hip extends and knee is flexed
- causes avulsion of its anatomic origin off the pelvis



PRESENTATION

- History = sudden "pop" in pelvis
- Symptoms: groin pain and weakness
- Physical exam
 - antalgic gait
 - anterior hip pain and hip flexion weakness

RADIOGRAPHS

- show avulsion of AIIS



TREATMENT



almost all



Nonoperative

- **bed-rest, ice, NSAIDs**
- hip flexed for 2 weeks
- follow with partial weight bearing for 4 week

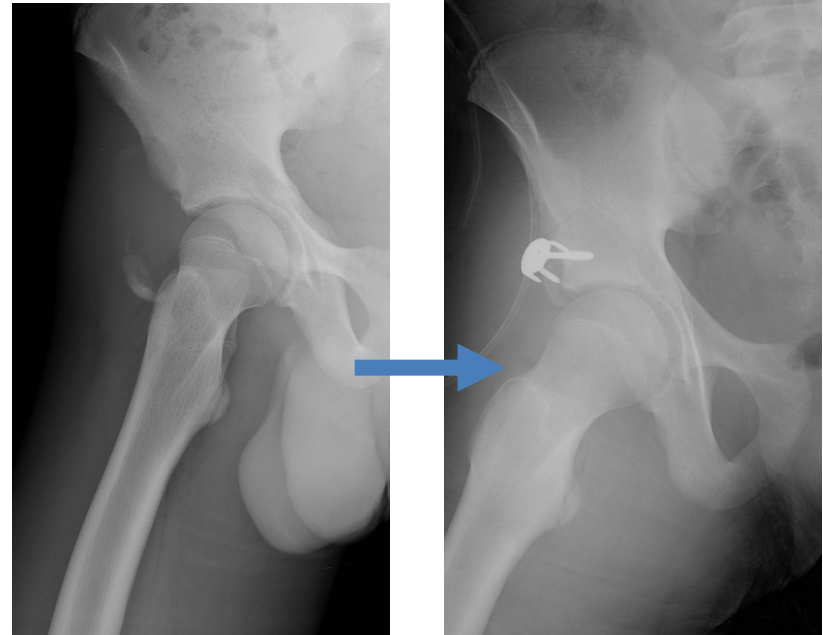
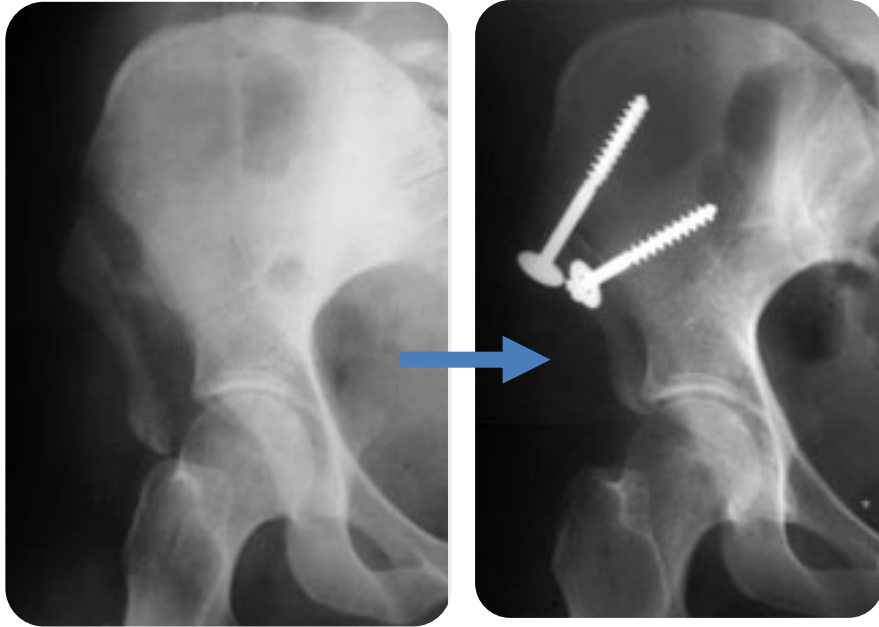
- large fragment
- significant displacement



Surgical: fixation



Surgical: fixation

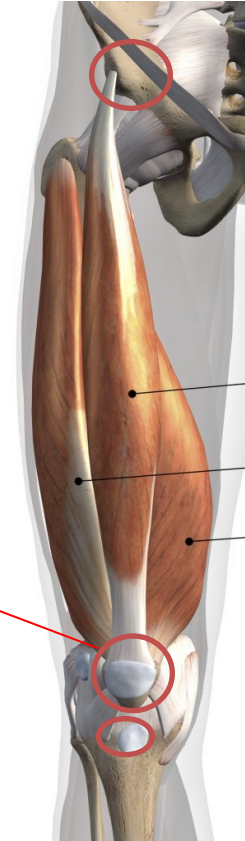


Anterior inferior iliac spine

Patella

- Bone
- Proximal avulsion (QT)
- Distal avulsion (PT)

Tibial tuberosity



MECHANISM

Direct trauma, anterior aspect ++++

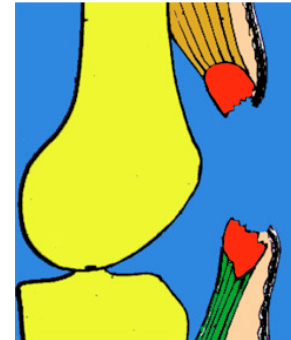
- Knee flexed, quadriceps contracted: displaced fracture
- **Compression against condyles/trochlea: comminuted fracture**
- Knee in extension: non-displaced fracture



Indirect trauma

(violent contraction of the quadriceps)

- Avulsion of the quadriceps
- Horizontal fatigue fracture (athlete)
- Sleeve fracture (child)



Clinical examination:

- Large knee
- Functional impotence
- May be partial
- Front pain
- Associated lesions ++



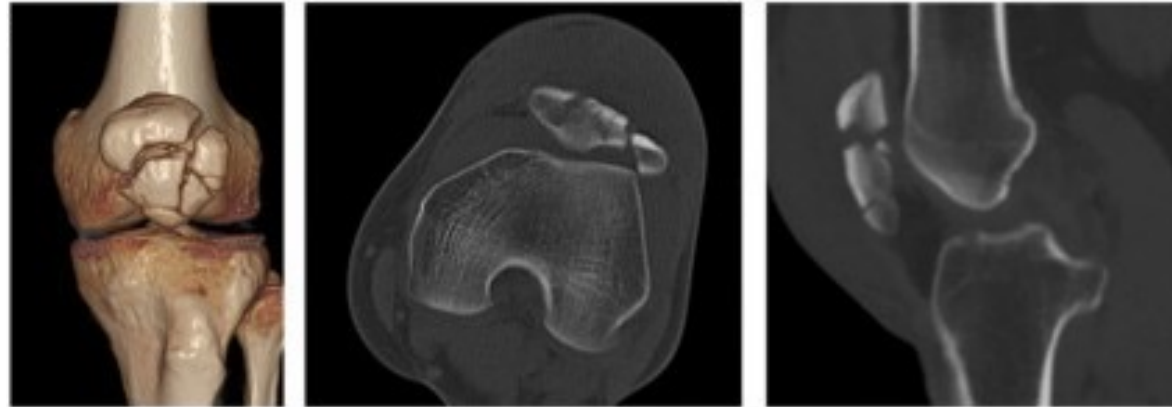
X-rays

- Face + Profil
- confirm diagnosis



CT scan

- pre op vizualisation, 3D+++



Classification

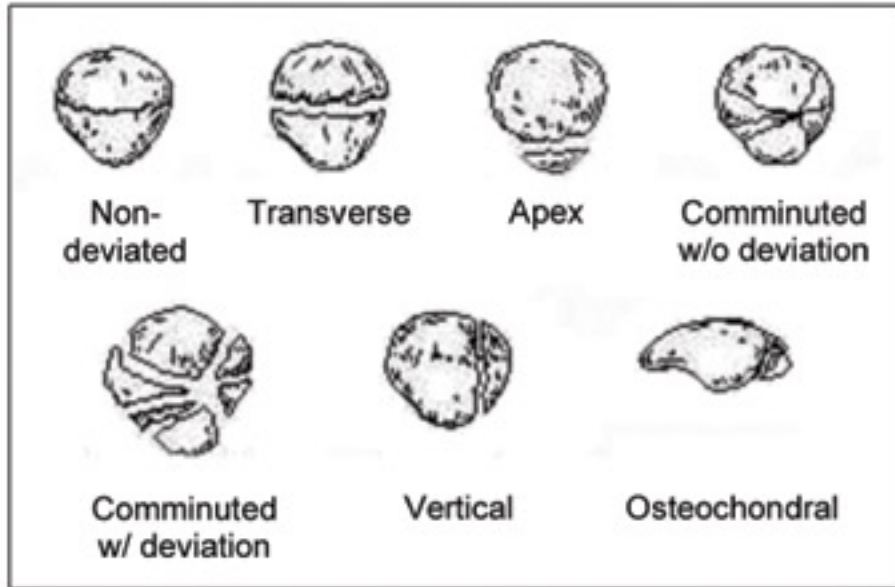
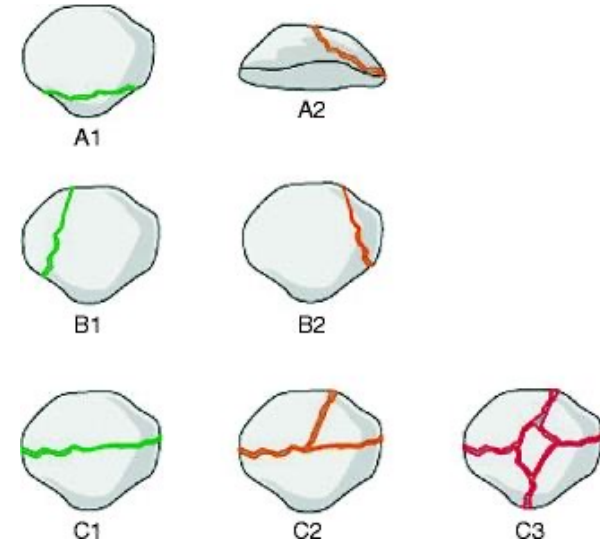


Figure 1 - Classification of patellar fractures



AO/OTA classification

- A: extra articular
- B: partial articular
- C: complete articular



Non operative treatment

Surgical treatment

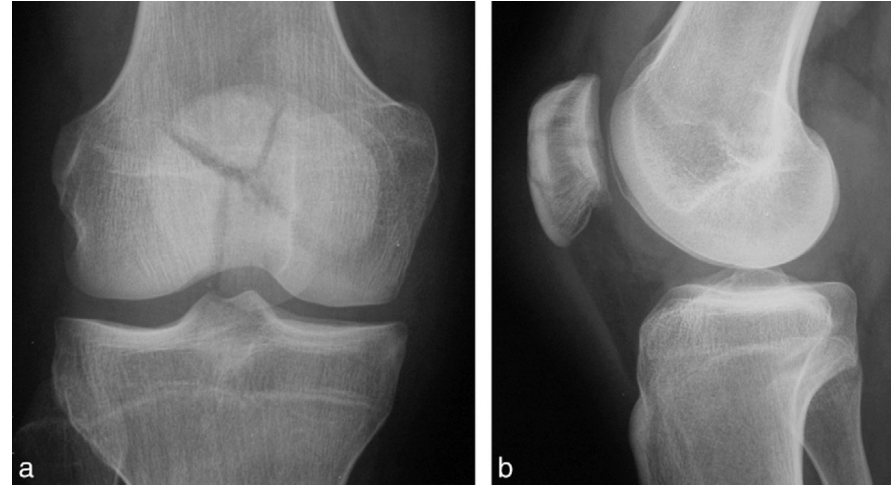
Treatment of complications

Non operative treatment

debatable

INDICATIONS:

- No discontinuity of extensor mechanism
- + Stable fracture (Rx profile at 60° flexion)
- + Joint step $\leq 1\text{mm}$
- + Interfragmentary diastasis $\leq 1\text{mm}$



Non operative treatment

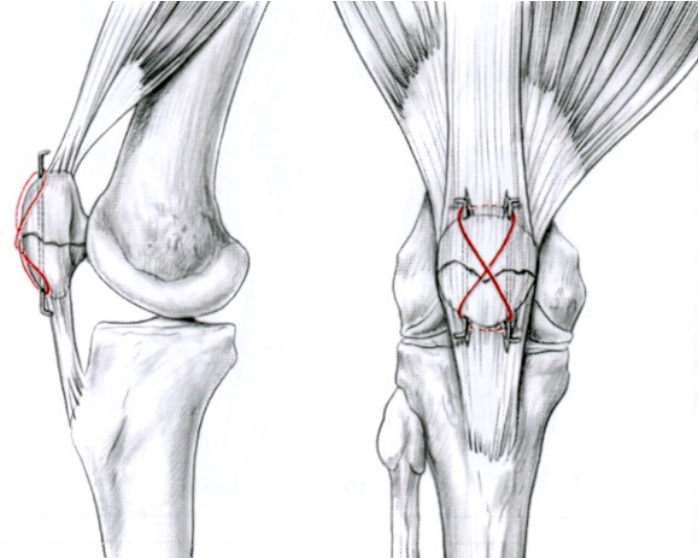
- Bracing 6 weeks
- Full weight bearing with brace
- Rehabilitation: passive
 - 0-30° 15J
 - 0-60° 15J
 - 0-90° 15J
- Regular follow-up: D7, D45...



Surgical treatment

INDICATIONS:

- discontinuity of extensor mechanism
- Unstable fracture
- Joint step $\geq 1\text{m}$
- Interfragmentary diastasis $\geq 1\text{mm}$



Surgical treatment

RULES: be delicate and cautious+++

- Skin is your friend: don't be aggressive
- Control the cartilage reduction
 - Small medial arthrotomy + digital palpation « *a little finger is better than big promises* »
 - intraoperative fluoroscopy
- Always control the quad and patellar tendons



Surgical treatment

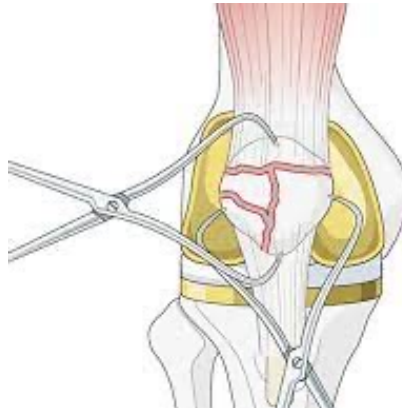
REDUCTION

- use the periosteum
- pulled and sutured
- close the package

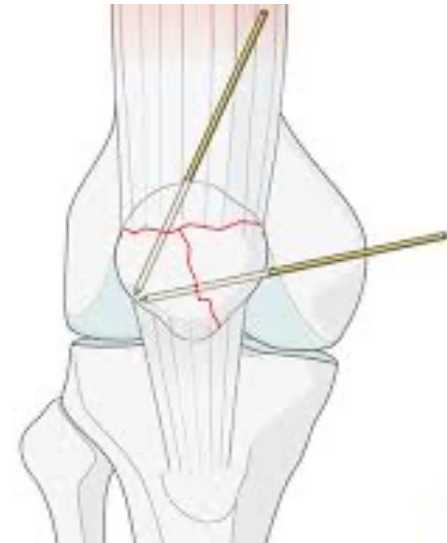


Surgical treatment

- if periosteum is damaged:
clamps
- + temporary K wire :1mm to 1.5mm



AO



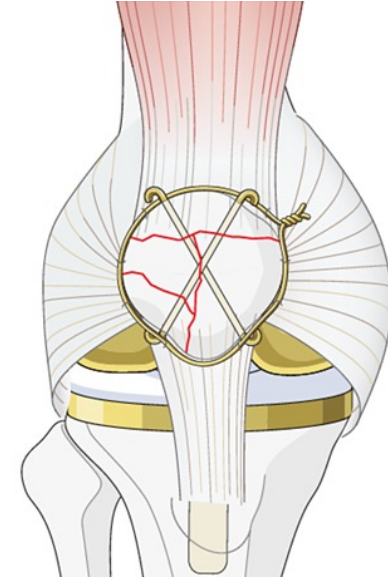
AO

Surgical treatment

OPTIONS for FIXATION:

- **K-wire + cerclage**
 - Titanium cerclage
 - Lag screws + cerclage
 - Cannulated Screw + tension bands
 - Plate
 - Patellectomy: partial, total

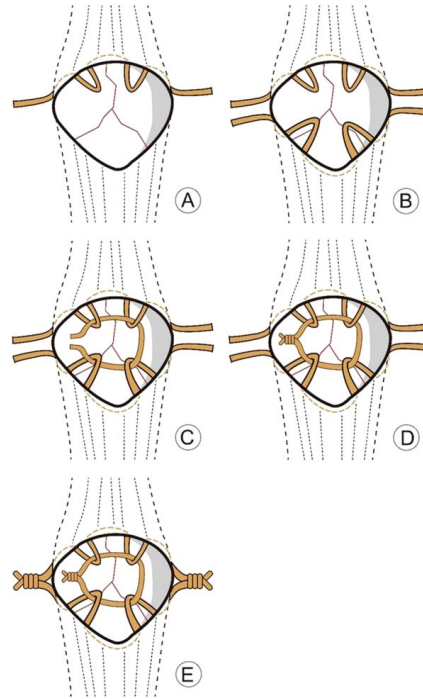
Equatorial cerclage
> figure 8



Surgical treatment

OPTIONS:

- K-wire + cerclage
- **Titanium cerclage**
- Lag screws + cerclage
- Cannulated Screw + tension bands
- Plate
- Patellectomy: partial, total

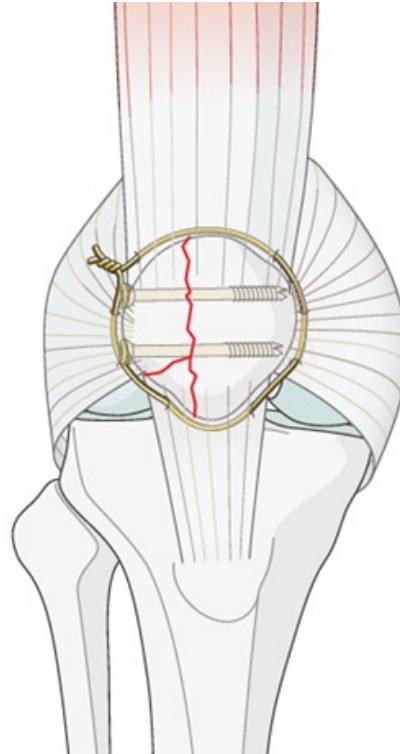


Surgical treatment

OPTIONS:

- K-wire + cerclage
- Titanium cerclage
- **Lag screws + cerclage**
- Cannulated Screw + tension bands
- Plate
- Patellectomy: partial, total

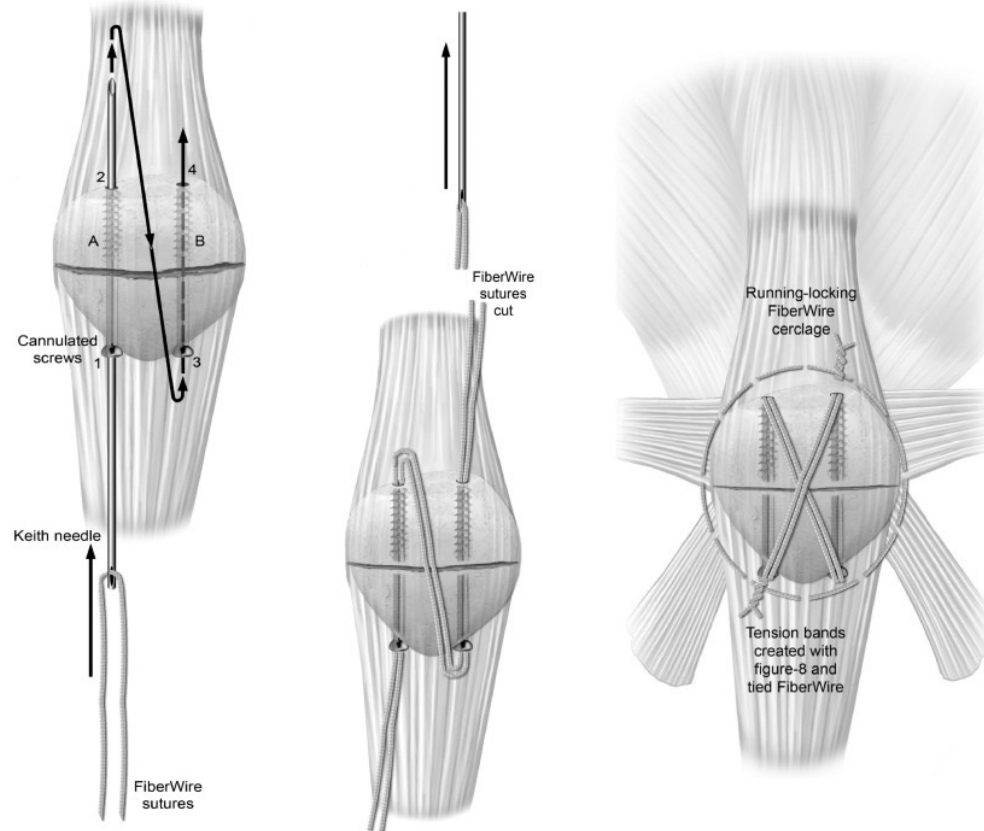
**Compression screws
(foot & ankle)
rarely isolated in comminutive fracture
+/- Equatorial cerclage
+/- K wire**



Surgical treatment

OPTIONS:

- K-wire + cerclage
- Titanium cerclage
- Lag screws + cerclage
- **Cannulated Screw
+ tension bands**
- Plate
- Patellectomy: partial, total

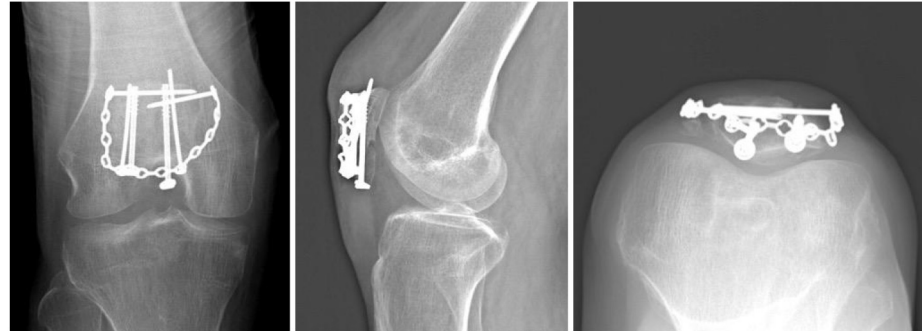


Surgical treatment

Be careful of the skin

OPTIONS:

- K-wire + cerclage
- Titanium cerclage
- Lag screws +/- cerclage
- Cannulated Screw +/- tension bands
- **Plate**
- Patellectomy: partial, total



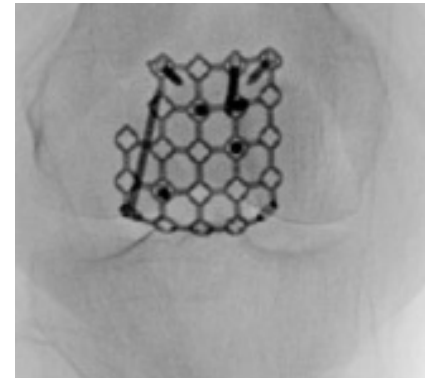
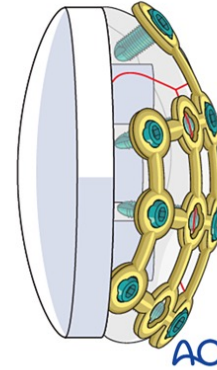
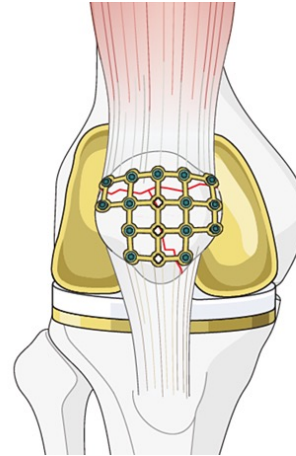
[patella rim plate](#)

Surgical treatment

OPTIONS:

- K-wire + cerclage
- Titanium cerclage
- Lag screws +/- cerclage
- Cannulated Screw +/- tension bands
- **Plate**
- Patellectomy: partial, total

locking plating

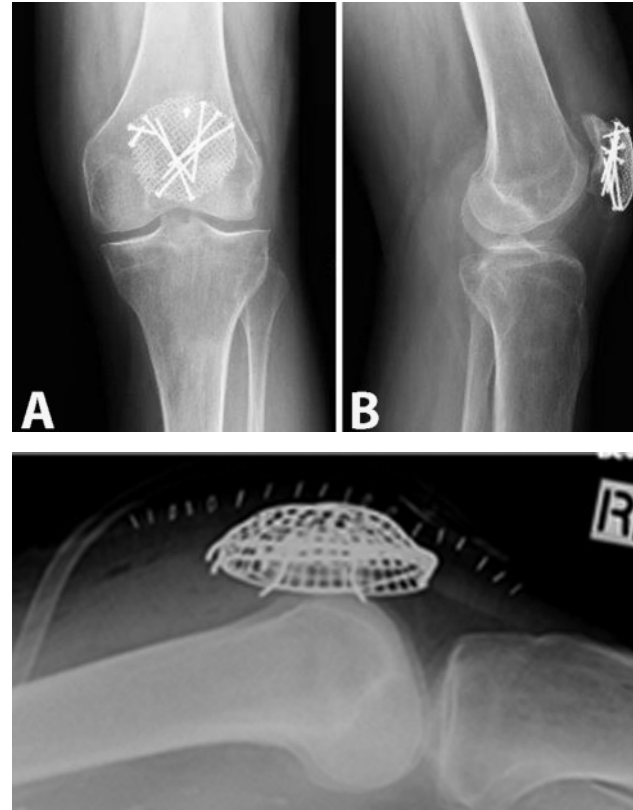


Surgical treatment

OPTIONS:

- K-wire + cerclage
- Titanium cerclage
- Lag screws +/- cerclage
- Cannulated Screw +/- tension bands
- **Plate**
- Patellectomy: partial, total

mesh plating



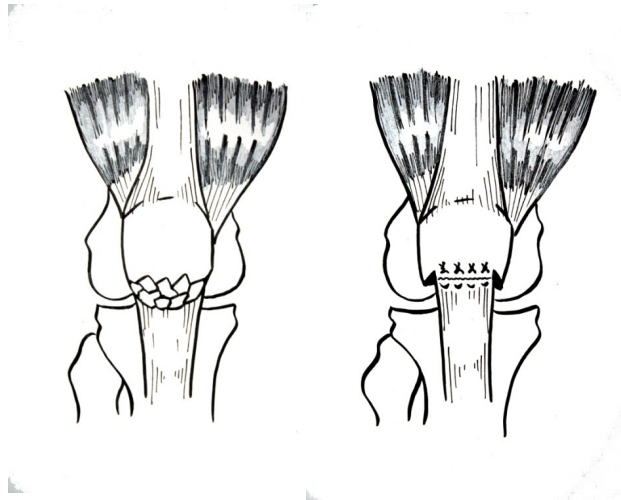
Surgical treatment

OPTIONS:

- K-wire + cerclage
- Titanium cerclage
- Lag screws +/- cerclage
- Cannulated Screw +/- tension bands
- Plate
- **Patellectomy: partial**

If highly comminutive fracture of
Proximal or distal

Then: reinsertion of the QT or PT



Surgical treatment

OPTIONS:

- K-wire + cerclage
- Titanium cerclage
- Lag screws +/- cerclage
- Cannulated Screw +/- tension bands
- Plate
- **Patellectomy: total**



To avoid+++
Last solution

COMPLICATIONS

- Skin issues: prevention
- Stiffness in flexion
- Patella Baja
- non-union
- mal-union

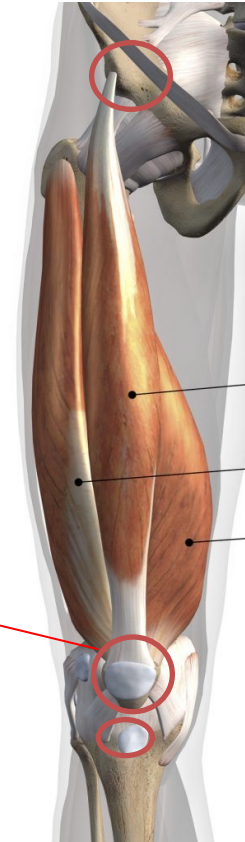


Anterior inferior iliac spine

Patella

- Bone
- Proximal avulsion (QT)
- Distal avulsion (PT)

Tibial tuberosity



History

- often report a history of pain leading up to rupture consistent with an underlying **tendonopathy**

Symptoms

- palpable defect superior pole of patella
- unable to extend the knee against resistance

Radiographs

- Fracture superior pole of patella
- **patella baja**



Treatment indications

Almost all cases

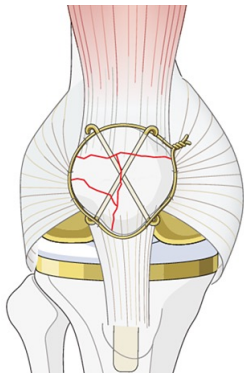


- only **if ORIF is NOT possible**
- comminuted extra-articular superior pole fracture
- Very small fragment (<5mm)

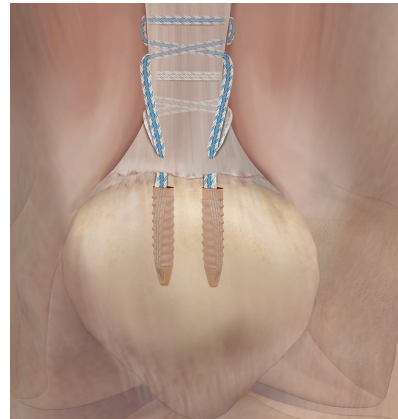


osteosynthesis

Fixation: anchors +++ (tape through the bone fragment)



AO

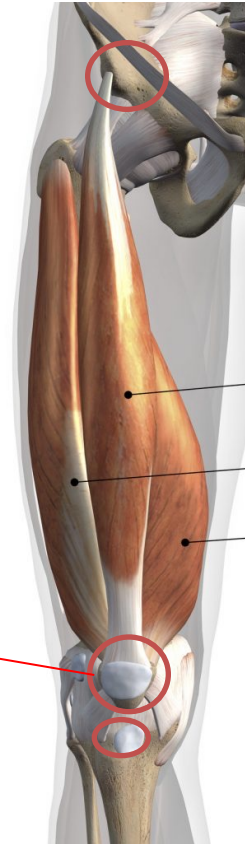


Anterior inferior iliac spine

Patella

- Bone
- Proximal avulsion (QT)
- Distal avulsion (PT)

Tibial tuberosity



History

- history of **jumping** event with sudden quadriceps contraction with knee in a flexed position (e.g., jumping sports, missing step on stairs)
- patient will often hear/feel a popping sensation

Symptoms

- infrapatellar pain
- immediate swelling
- difficulty weight-bearing

Physical exam

- **patella alta**
- palpable gap below the inferior pole of the patella
- unable to perform active straight leg raise or maintain passively extended knee
- if only tendon is ruptured and retinaculum is intact, active extension will be possible but will have extensor lag of a few degrees

Radiographs

- Fracture inferior pole of patella
- patella alta



Treatment indications

Almost all cases



- comminuted extra-articular inferior pole fracture measuring <40% patellar height
- only **if ORIF is NOT possible**
- Very small fragment (<5mm)



osteosynthesis

Partial patellectomy + tendon advancement

Comparative Study > J Bone Joint Surg Am. 2004 Apr;86(4):696-701.

doi: 10.2106/00004623-200404000-00005.

Inferior patellar pole avulsion fractures: osteosynthesis compared with pole resection

Matej Kastelec¹, Matjaz Veselko



AO



Osteosynthesis > pole resection



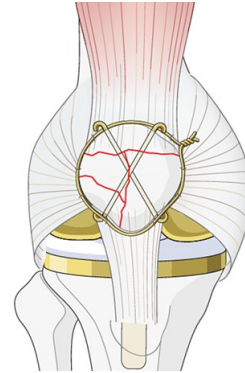
AO

Treatment

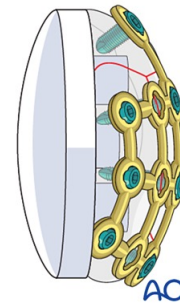
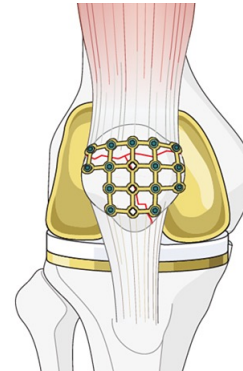
osteosynthesis

techniques

- K-wire + cerclage
- Lag screws +/- cerclage
- Cannulated Screw +/- tension bands
- plate



AO



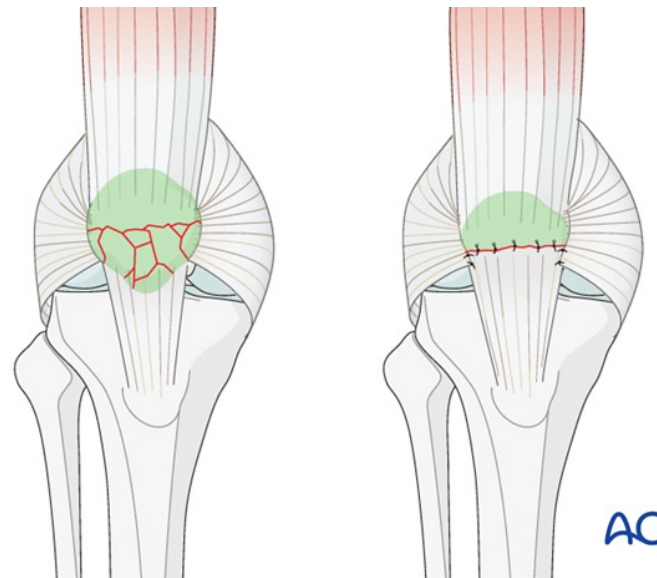
AO

Treatment

Partial patellectomy + tendon advancement

techniques

- remove least bone possible
- patellar tendon should be advanced into defect on anterior surface of patella
- suture anchor tendon repair : ≥ 2 anchors
- +/-protection with a cerclage wire or tape or gracilis between patella and TT

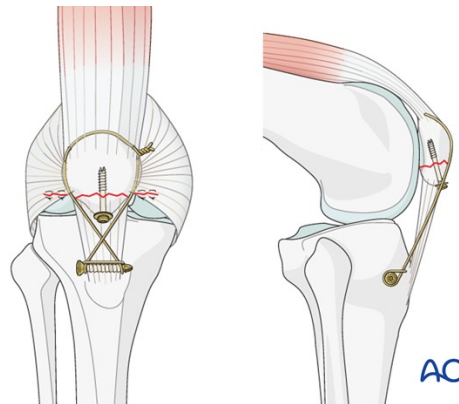
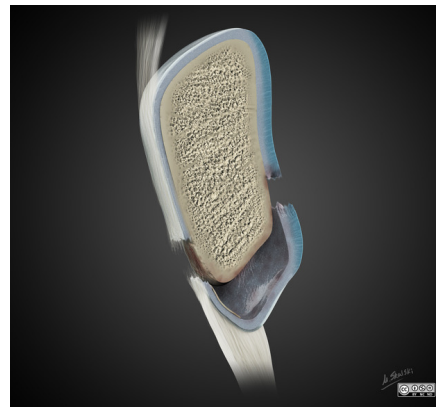


Patellar sleeve fracture

occurring in the **skeletally immature population**

the displaced bone-forming tissue will continue to grow and ossify, enlarging, and possibly duplicating the patella

Surgical treatment is recommended when there is significant displacement (>2 mm) of the displaced osteo/chondral fragment.

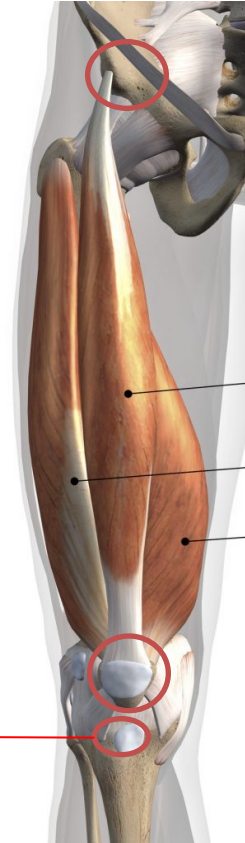


Anterior inferior iliac spine

Patella

- Bone
- Proximal avulsion (QT)
- Distal avulsion (PT)

Tibial tuberosity



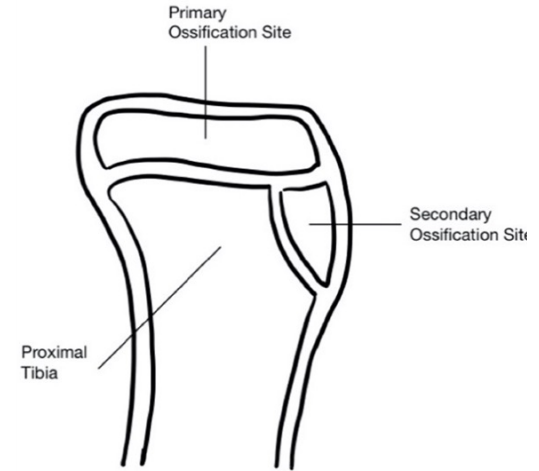
EPIDEMIOLOGY

- **Incidence:** <1% of pediatric fractures
- **Demographics:** males >> females, ages 12 - 15 (approaching skeletal maturity)
- **Risk factors:** most common in basketball, football, sprinting and high jump

PATHOPHYSIOLOGY

Mechanisms of injury

- a concentric contraction of the quadriceps during jumping
- an eccentric contraction of the quadriceps during forced knee flexion



Symptoms

- sudden onset of pain
- generally occurs during the initiation of jumping or sprinting
- inability to immediately ambulate
- knee swelling/hemarthrosis with Type III injuries

Physical exam

- inspection & palpation
- knee effusion
- tenderness at the tibial tubercle
- evaluate for **anterior compartment firmness**
- extensor lag or extensor deficiency in Type II or III injuries
- retinacular fibers may allow for active extension

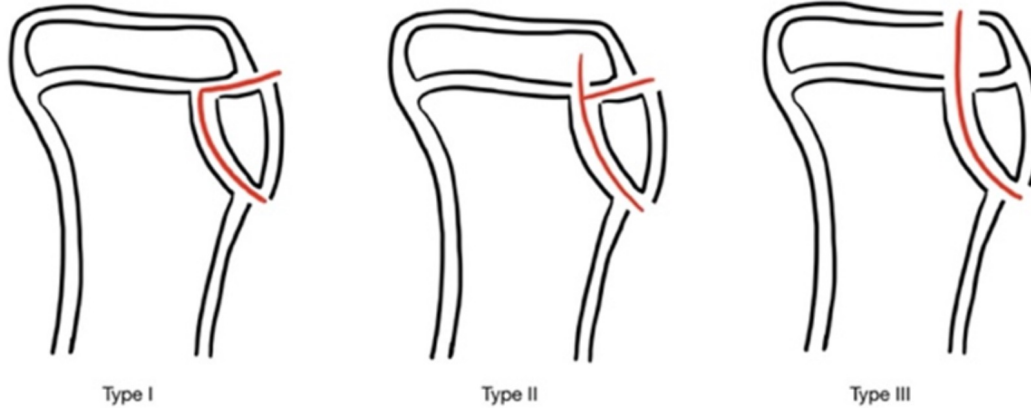


Table 2. Watson-Jones classification of tibial tubercle avulsion fractures.

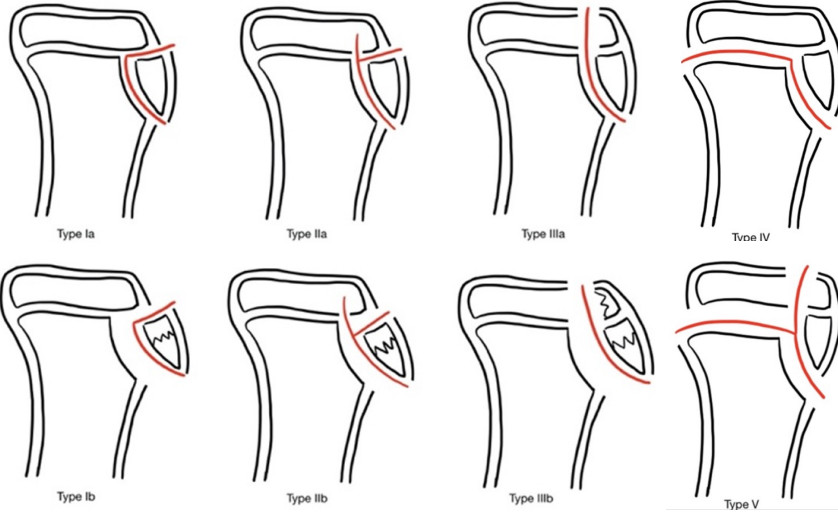
Type	1	Avulsion of the apophysis without injury to the tibial epiphysis
	2	Epiphysis is lifted cephalad and incompletely fractured
	3	Displacement of the proximal base of the epiphysis with the fracture line extending in the joint

Tibial tuberosity

T. Neri

HCL
HOSPICES CIVILS
DE LYON

HÔPITAL
LYON SUD



Ogden Classification (modification of Watson-Jones)

Type I	Fracture of the secondary ossification center near the insertion of the patellar tendon
Type II	Fracture propagates proximal between primary and secondary ossification centers
Type III	Coronal fracture extending posteriorly to cross the primary ossification center
Type IV	Fracture through the entire proximal tibial physis
Type V	Periosteal sleeve avulsion of the extensor mechanism from the secondary ossification center
Modifier: A (nondisplaced), B (displaced)	

TREATMENT

- **Type I** injuries or those with minimal displacement (< 2 mm)
- acceptable displacement after closed reduction/cast application



Nonoperative

- long leg cast in extension for 6 weeks
- indications

- **Type II-IV** fractures
(need to visualize joint surface for reduction)
- soft tissue repair for Type V (periosteal sleeve) fracture



Operative

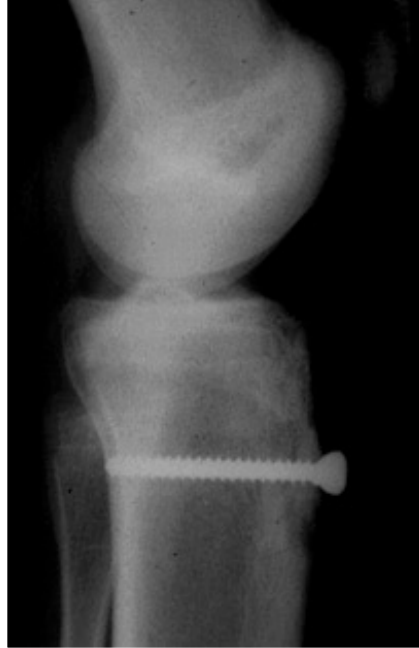
- open reduction internal fixation with arthrotomy +/- arthroscopy, +/- soft tissue repair
- indications

Tibial tuberosity

T. Neri

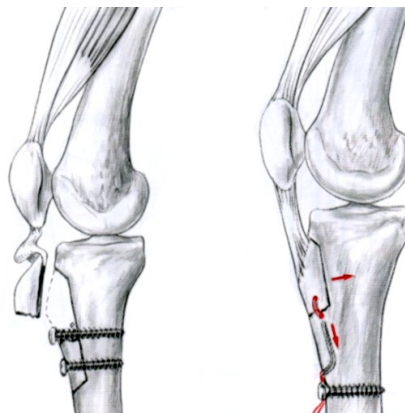
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HÔPITAL
LYON SUD

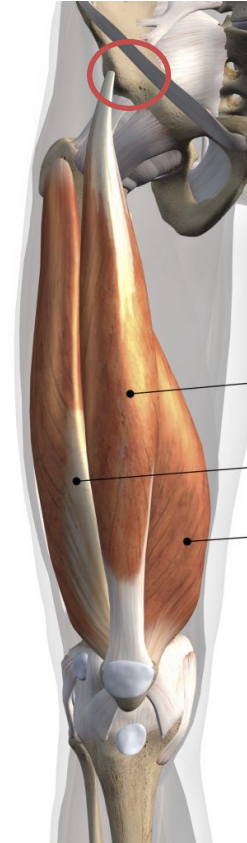


ADULT: setting of previous surgery

- TT transfer or elevation
- TKA



CONCLUSION



Anterior inferior iliac spine (AIIS) avulsion

- **apophyseal avulsion**
- **adolescent** athletes as a result of eccentric contraction of the rectus femoris.
- Diagnosis = pelvis **radiographs**
- Treatment is **nonoperative** with rest, icing, NSAIDs and activity modification.

Patella: bone

- **Direct** high energy trauma
- Diagnostic: Ask **CT-scan**
- Treatment is difficult
 - No winner
 - know **all the options** to choose the most adapted
 - respect rules : be careful of **skin**, small **arthrotomy** to check the cartilage reduction

Patella: proximal avulsion (QT)

Treatment indications

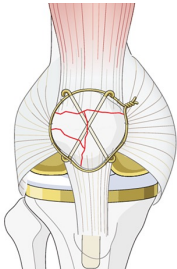
Almost all cases



- only **if ORIF is NOT possible**
- comminuted extra-articular superior pole fracture
- Very small fragment (<5mm)

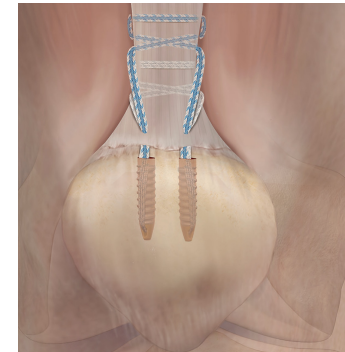


osteosynthesis



AO

Fixation: anchors +++



Patella: distal avulsion (PT)

Treatment indications

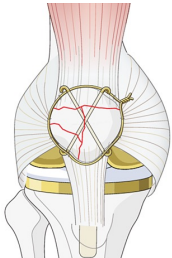
Almost all cases



- comminuted extra-articular inferior pole fracture measuring <40% patellar height
- only **if ORIF is NOT possible**
- Very small fragment (<5mm)

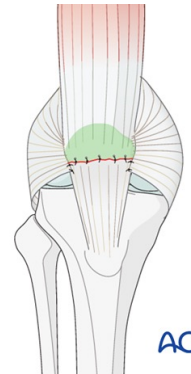


osteosynthesis



AO

Partial patellectomy
+ tendon advancement



AO

Tibial Tubercle Fractures

- **adolescent** near the end of skeletal growth during athletic activity.
- Diagnosis = **radiographs**
- Treatment may be **nonoperative** or **operative** depending on location of the fracture, degree of displacement, and any associated injuries.
- For adult: secondary to previous surgery: TT transfer, TKA