European Knee Society

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Complex Articular Fractures

Childhood specificity

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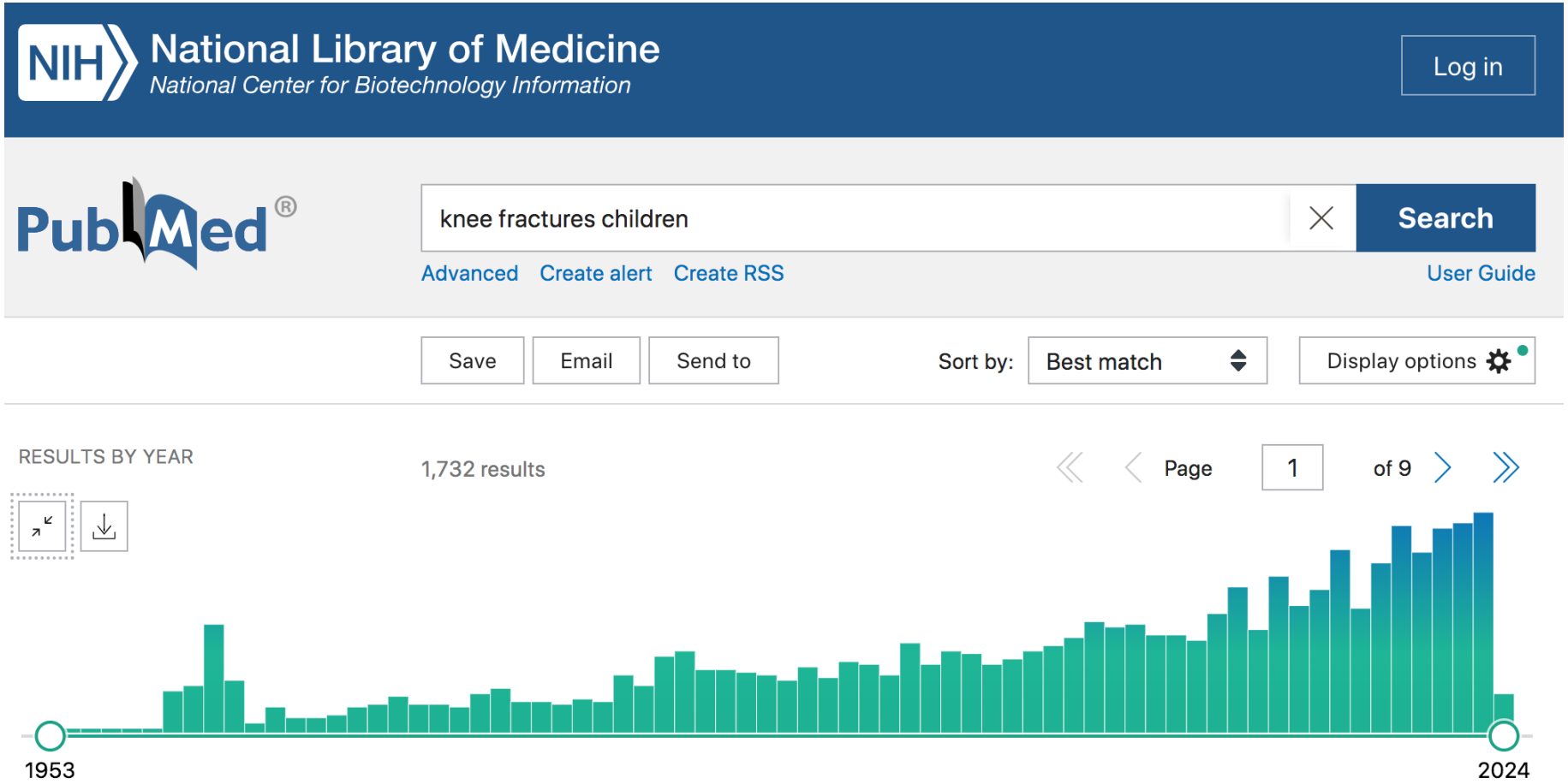
What we know and what the literature tells us



Increasing interest over the years,

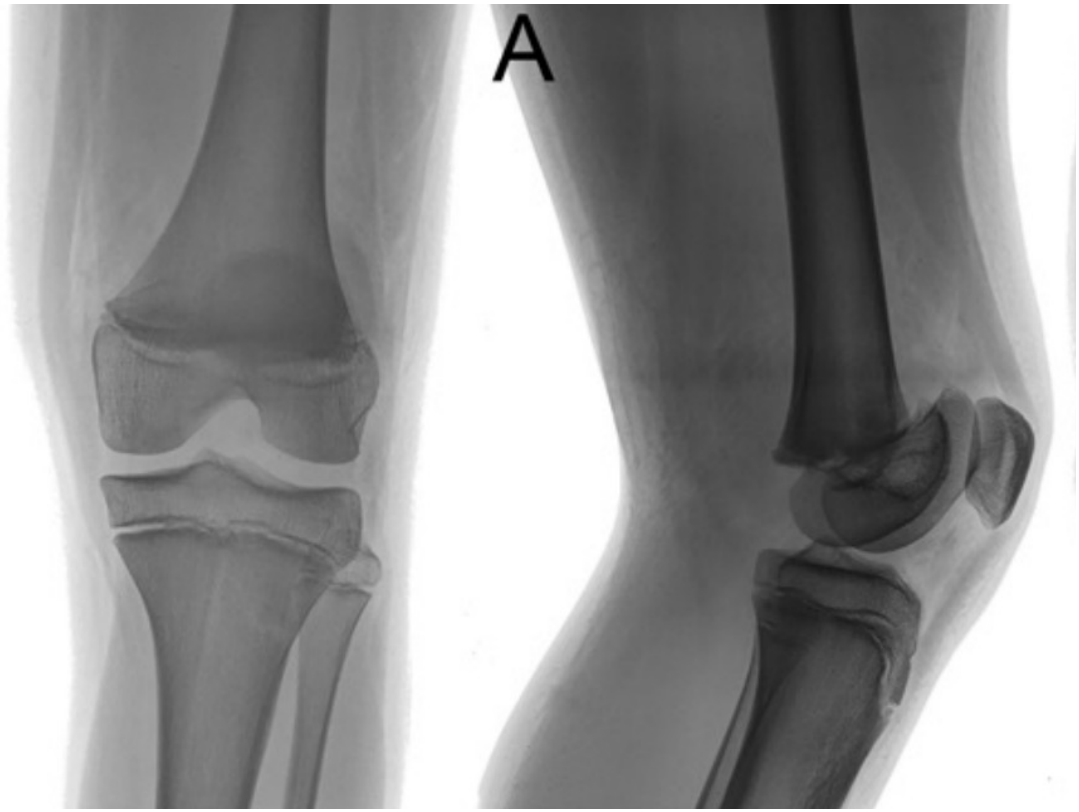
but let's go to the ski run…

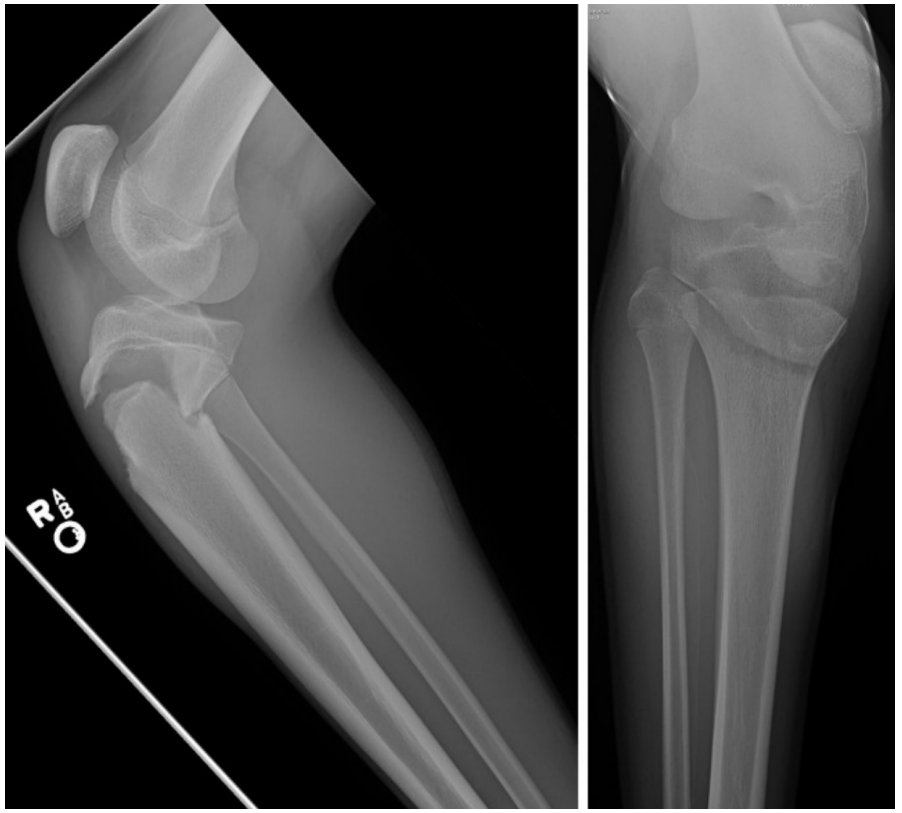
Skier, 14y

Knee injury

Salter Harris type II

Growth Plate Injuries





The main complication is growth disturbances secondary to growth-plate injury

Growth Plate Injuries

Fractures involving the femoral or tibial physis are relatively infrequent.

The growth plate of the distal femur grows at a variable rate of 8–10 mm/year, is responsible for 40% of the total growth of the lower limb, and closes approximately at the age of 13 years for females and 15 years for males.

The growth plate of the proximal tibia grows by 6 mm per year and closes approximately at the age of 14–15 years.

Only 0.3–0.4% of all epiphyseal detachments.

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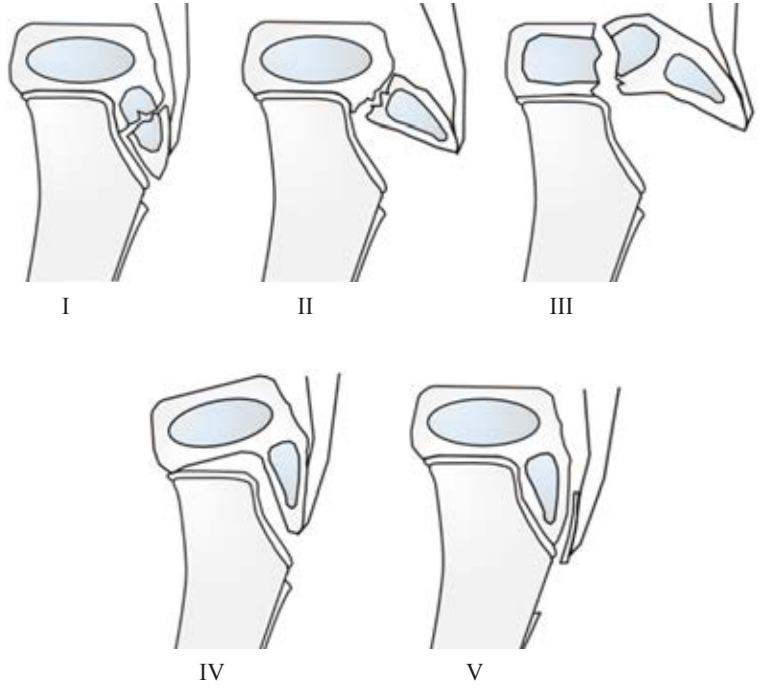
Proximal tibia – Tibial Tuberosity Avulsion Fracture

Specificity: proximal tibia ossification center begins to ossify from posterior-medially to anterior-laterally and then from proximal to distal. The tibial tubercle is the last

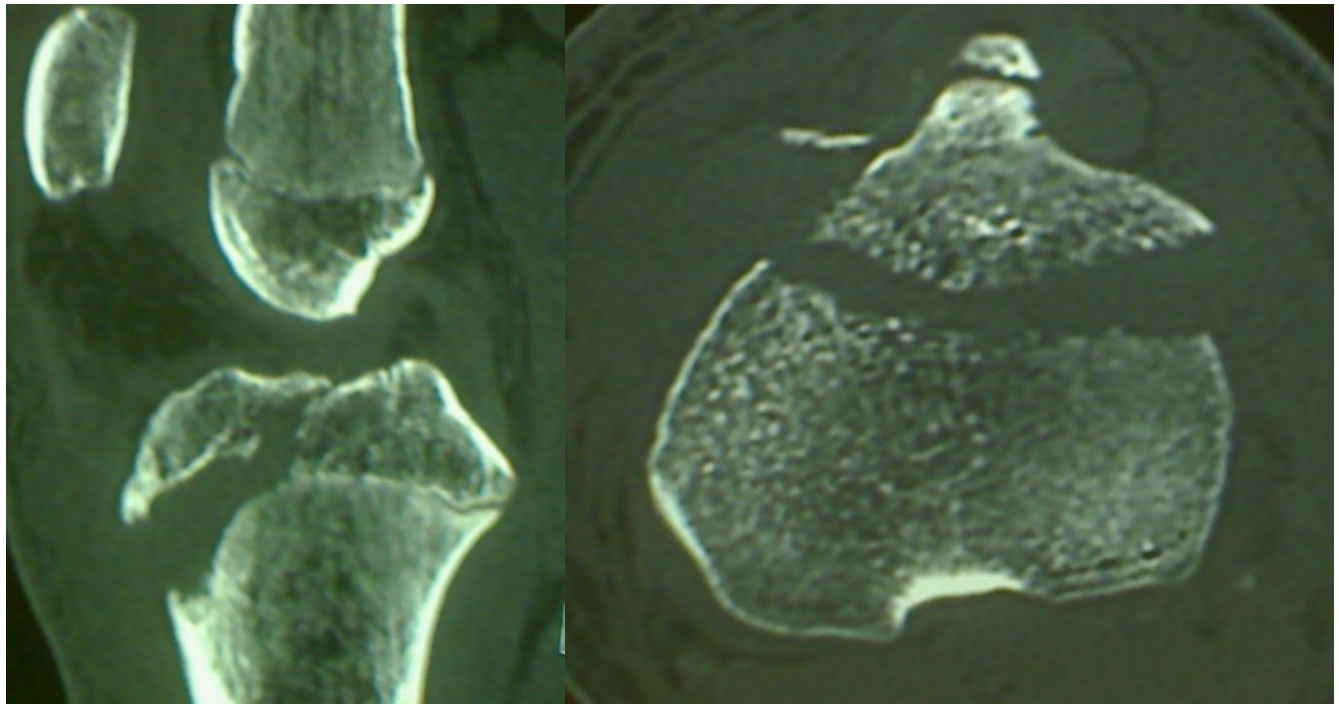
A concentric contraction of quadriceps during jumping or an eccentric contraction during knee flexion produce the fracture



Ogden classification

TTAF - Treatment

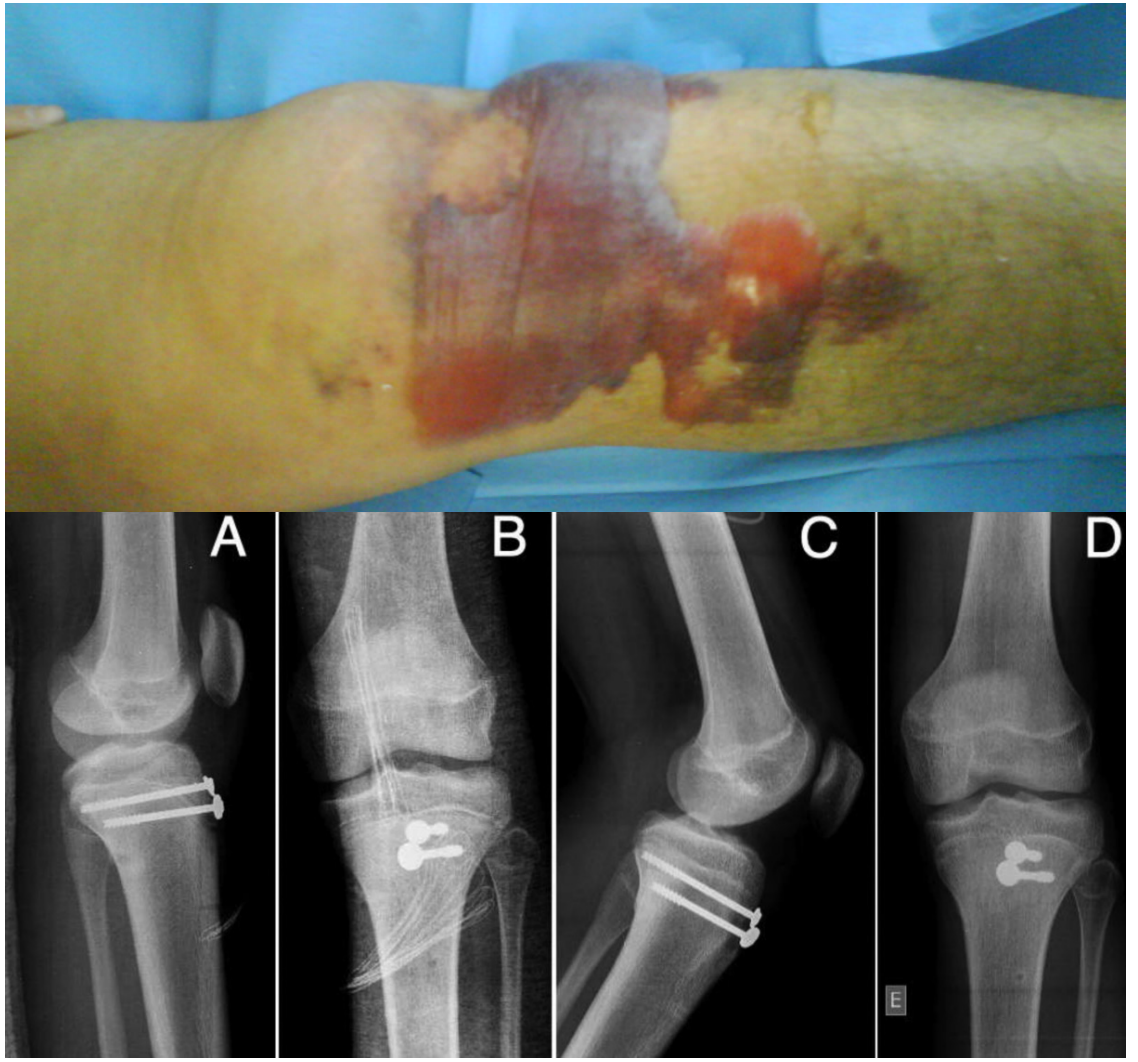
- Cast for Type 1 and non displaced fractures
- ORIF for displaced and intra-articular (>2mm)
- Medial parapatellar incision or centered over the fracture site to assess articular damage
- 4,5 mm cannulated screws avoiding the physis



TTAF - Treatment

- In the OR as soon as possible
- High risk of skin compartment syndrome
- Prophylactic fasciotomy?
- Ogden 1-2-3 return to sport at 3 months
- Ogden 4-5 return to sport at 4-6 months

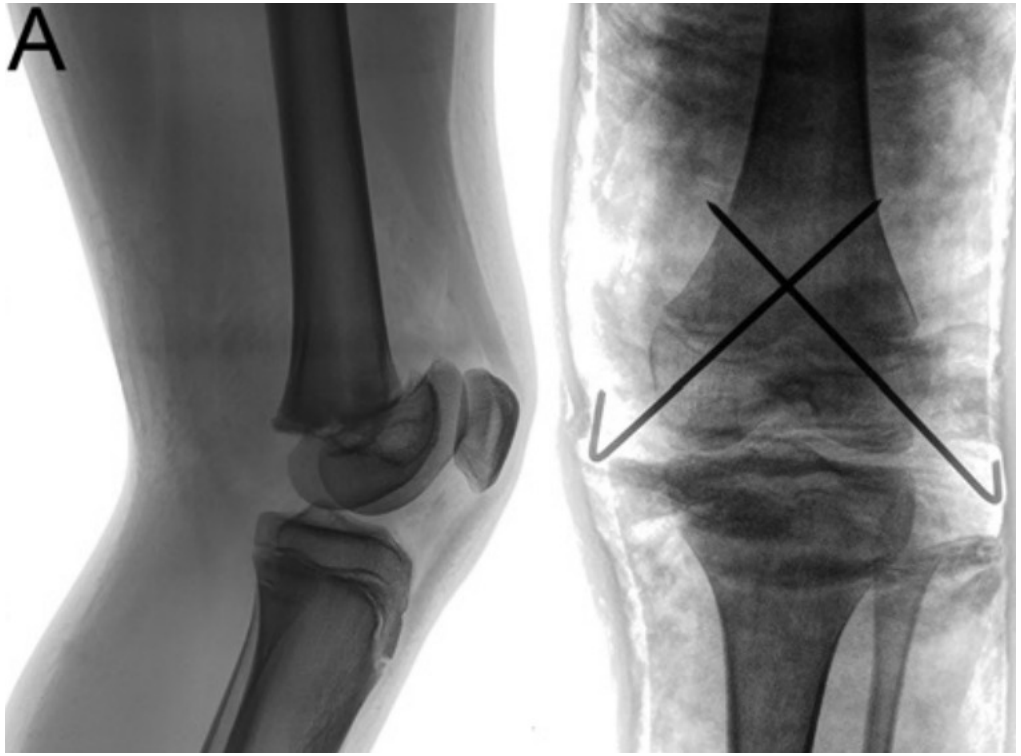
Franz et al 2020



70% of lower limb growth is around the knee

Fractures are more frequent than ligamentous injuries

Great amount of cartilage



Fractures can cause

- limb length discrepancies
- angular deviations
- chronic pain
- ROM deficit
- residual laxity and instability

Fractures involving extensor mechanism may cause

- functional impairment
- extension lag

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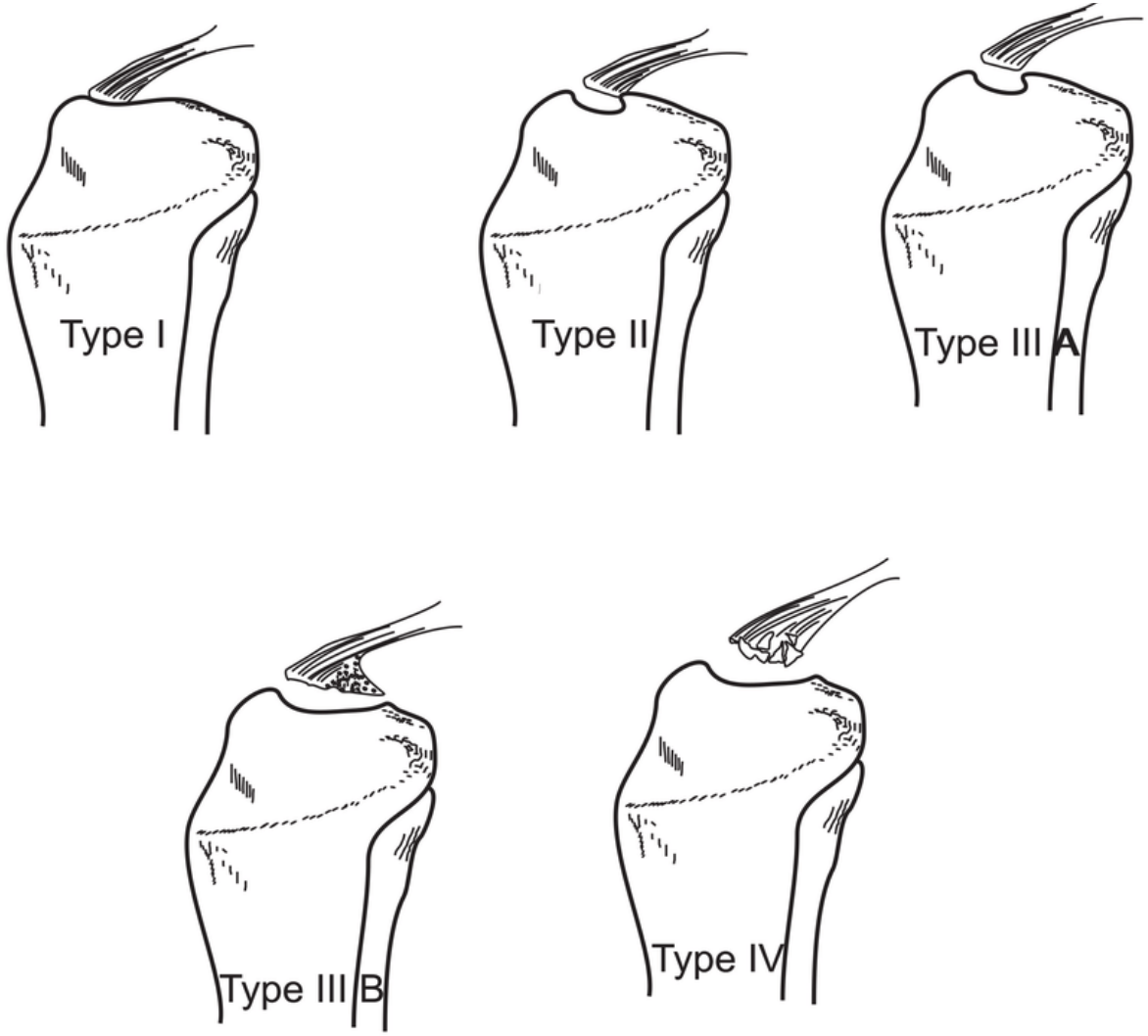
Tibial spine fractures

- 8-14 ys
- 3 fx /100000
- 2-5% of pediatric injuries associated with an effusion
- Historically bycicle injuries
- More frequently non contact sport, soccer, skiing
- Mechanism similar to that of ACL injuries: forceful knee flexion while the tibia is externaly rotated

Meyers and McKeever Classification (1970)

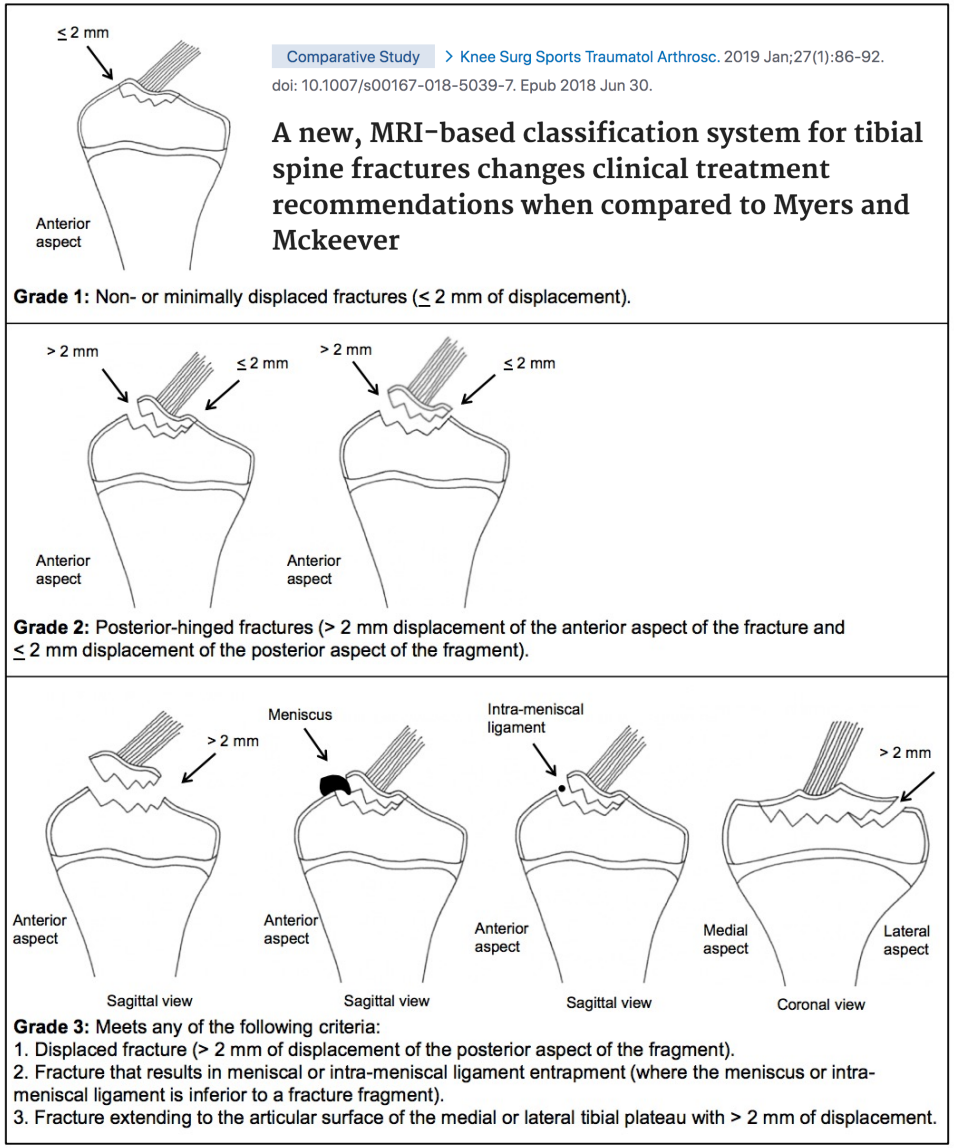


Meyers & McKeever

mod Zaricznyj

Type I	non displaced
Type II	posterior hinge
Type III	displaced
Type IV	comminuted

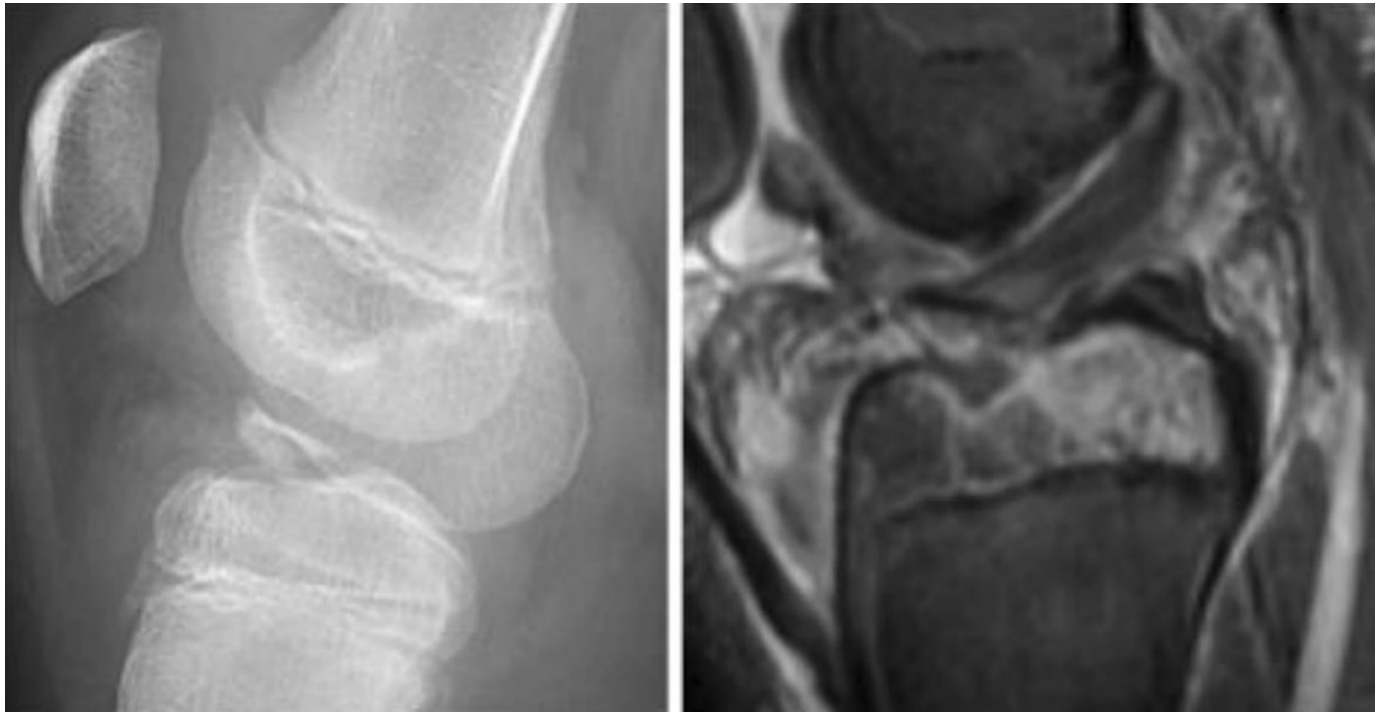
Green Classification (2019)



Xray and CT scan are not enough

- Mitchell et al 2015, Rhodes et al 2018 Shea et al 2011 report **meniscal tears** in 29-40%, **meniscal entrapment** 35%
- In younger patient the fragment detached can be purely of cartilage (very difficult to be adequately visualized by CT)
- In minimally displaced lesions MRI can be very useful prior to decide non operative treatment as stated by Rhodes et al 2018

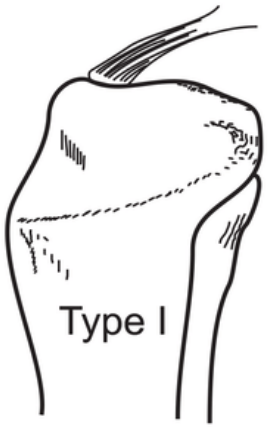
Green Classification (2019)



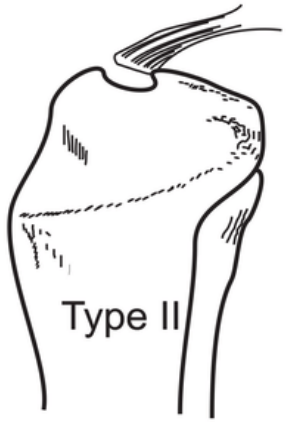
The MRI-based system provides specific, quantitative criteria for classifying fractures according to fragment displacement and tissue entrapment.

The new MRI-based system potentially clarifies treatment indications for tibial spine fractures.

Treatment



Non surgical



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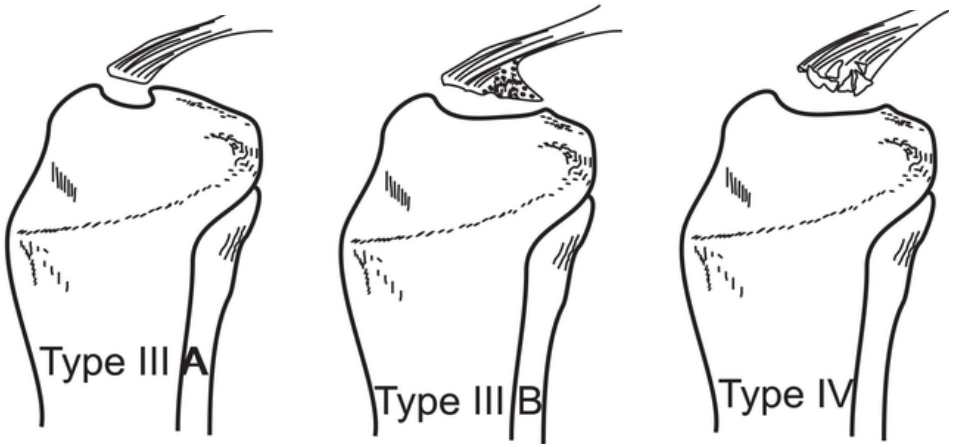


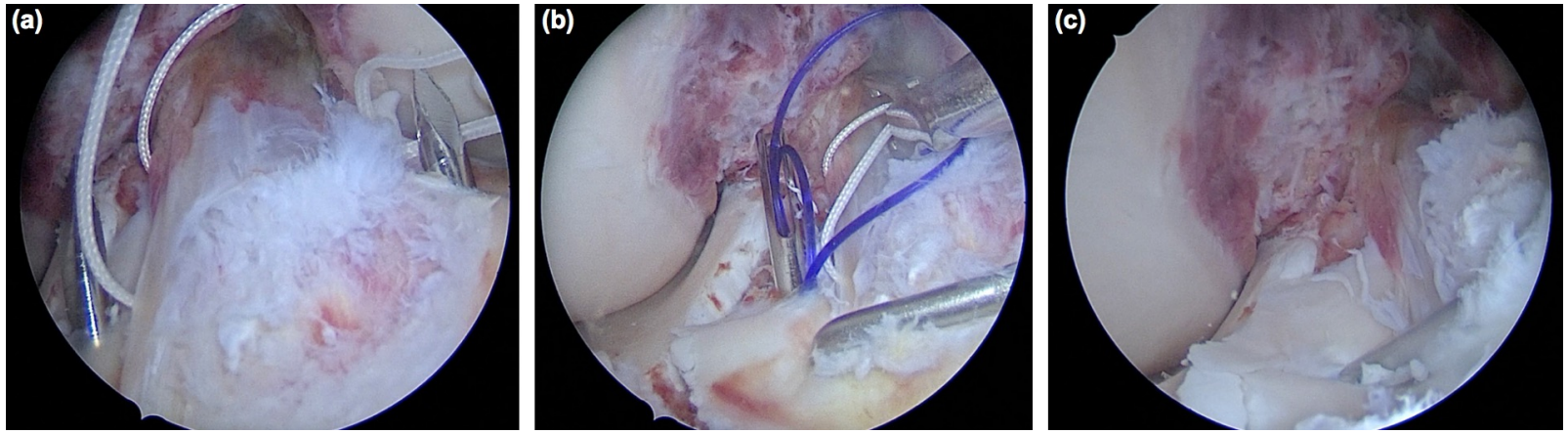
Surgical

Type IIIA only the insertion of ACL
Type IIIB the intercondylar eminence
Type IV comminuted (added by Zaricznyj)

Treatment

Type II surgical if good closed reduction but there is debate regarding management of this subgroup

- Kocher et al 2003, Mulhall et al 1999, Mitchel et al 2015, Lafrance et al 2014 suggest operative treatment also in this group
- Edmonds et al 2015 suggest non operative treatment if displacement less than 5 mm, and surgical intervention provide better reduction but with a big arthrofibrosis risk
- Frequent soft tissue entrapment (intermeniscal ligament? meniscus itself?)



ARIF vs ORIF

Many studies report equivalent or better outcome with ARIF

Callaman et al 2019

BUT

Small, retrospective studies including adults

Binet et al 2001, Kendall et al 1992,Matthews et al 1994

In a recent sistematic review patient with ARIF had greater ROM deficit, and more anterior laxity than those with ORIF, arthrofibrosis rate being the same

Gans et al. 2014

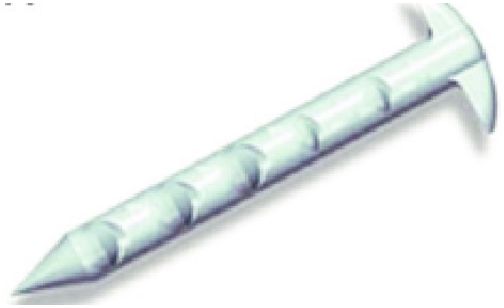
Surgical delay: operative times are significantly longer and associated with risk of arthrofibrosis

Watts 2016

How to fix

- Headless screws
- Cannulated screws
- K wires

- Absorbable suture
- Non absorbable sutures
- Suture anchors
- Suture bridge and cortical buttons
- Lasso
- Meniscus arrows



Metal screws

Pan et al. 2012

- better IKDC score
- less pivot shift laxity
- shorter operative times
- (bias: the cohort included adult patients)

Osti et al. 2016 (syst.rev.)

- Shorter postoperative rehabilitation
- Earlier weight bearing
- more aggressive rehab

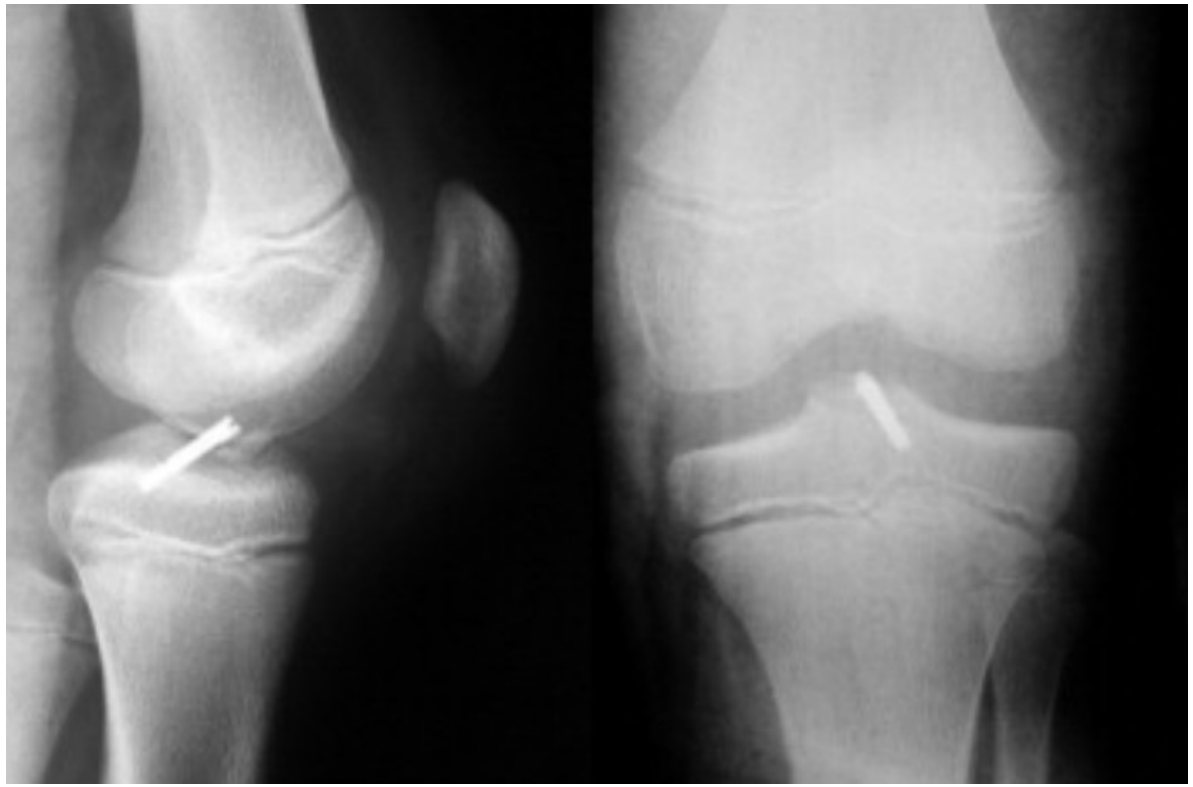
Metal screws

Hunter et al 2004, Hirschmann et al 2009

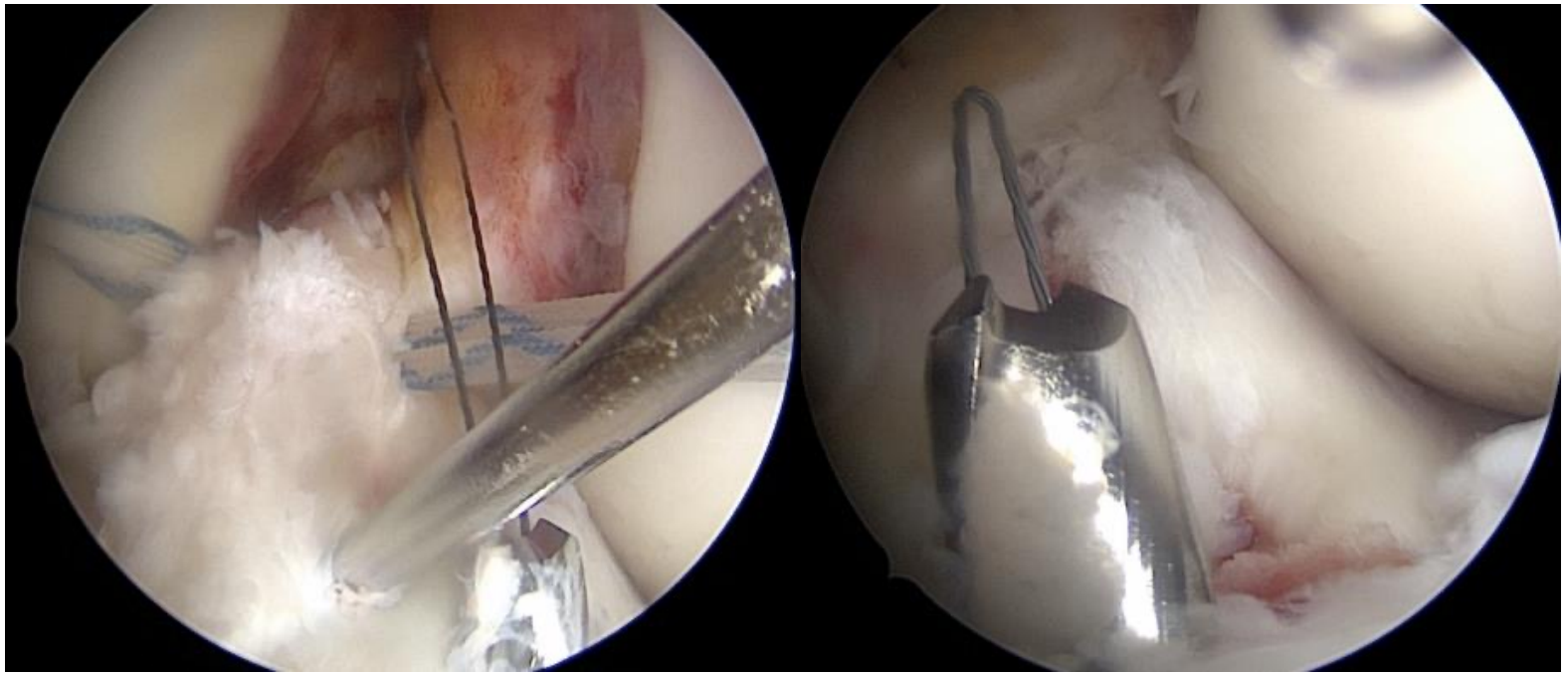
- Growth issues
- Need for reoperation
- Articular surface damage

Furlan et al 2010, Bonin et al 2007

- Headless screws and K-wire had decreased articular damages and need of hardware removal



Suture technique



Eggers et al 2007, Senekovic et al 2014, Waghi et al 2015

- Stronger and longer reduction under cyclic load as in physiologic knee activity

Bogunovich et al 2015 (syst rev)

- Lower rate of clinical laxity tested (KT 1000 and Lachmann test)
- No difference in patient reported instability

Suture technique
absorbable vs non absorbable

Brunner et al 2016, Liao et al 2016

- No clinical and radiological significative differences

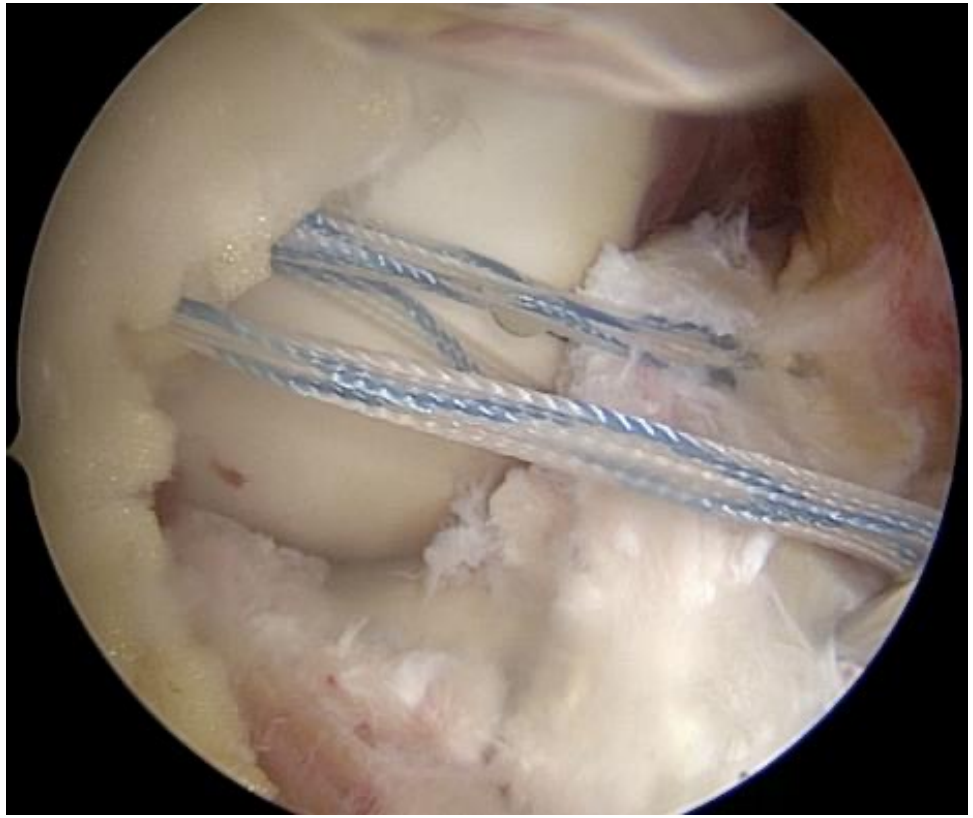
Suture anchor

Xuu et al 2017:

- Improved outcomes (KT 1000, Tegner, IKDC, Lysholm)
- No differences in patient reported instability

Bley et al 2017

- Avoid proximal physeal damage
- Provide strong low-profile suture fixation



Other techniques – small series

- Tension band with wire around a screw

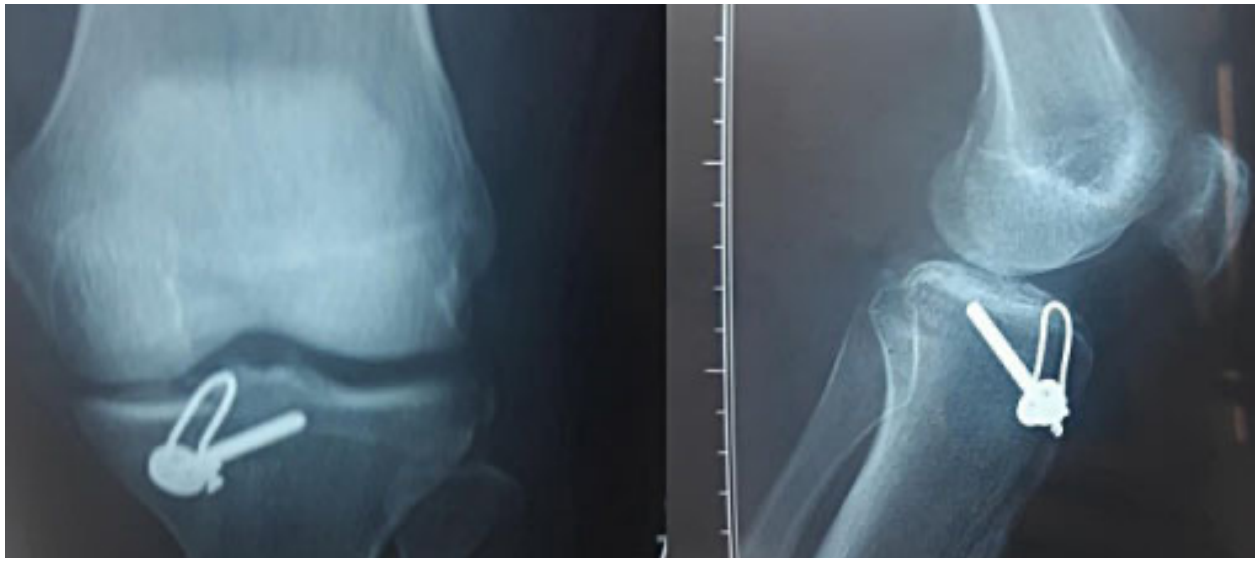
Archer et al 2016

- High strength nonabsorbable suture with cortical button

Zhang et al 2017, Memisoglu et al 2016

- Hybrid K-wire and suture construct

Zhao et al 2015



Arthrofibrosis

- For surgically treated 10-30%

Gans et al2014, Bram et al 2020, Vander Have et al 2010

- Concomitant ACL tear
- Non sport related injury
- Long immobilisation
- Patient younger than 10

Bram et al 2020

- Long surgical time

Vander have 2010

- If rehab starts later than 4 wks from surgery arthrofibrosis is 12 times more likely to develop

Patel 2012

Tibial Spine Fractures - THM

- Retrospective studies
- Small series
- Heterogenicity of surgical techniques

  (many solution to a problem = no gold standard)
- Successful outcomes both with ARIF and ORIF but with low level of evidence
- No consensus about superiority of any suture technique
- In recent literature lateral extrarticular tenodesis augmentation diminishes failure rate in patient treated with ACL recon, no studies about the same issue in TSF

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Sleeve fractures

- Rare and almost seen in skeletally immature patients
- X-rays detect big fragment
- For little fragments MRI is necessary
- Location
  - Proximal patellar pole
  - Distal patellar pole (most frequent one)
  - Tibial metaphysis
-  Differential diagnosis with Sinding Larsen Johanson sd

Sleeve fractures treatment

- Suture anchor
- Small screws
- Tension band wiring
- Reparation of torn retinaculum, patellar or quadriceps tendon (often associated)
- 4 weeks immobilisation
- Perkins et al 2021 in the largest series reported good results with transosseous fixation

Sleeve fractures complications

Non adequate treatment choice or non timely treatment can lead to:

- Malunion
- Patella alta
- Anterior knee pain
- Quadriceps atrophy
- Extension lag

Severe limitations in daily activities

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Take Home Message

Complex articular fractures around the knee in pediatric patients have some peculiarities that differentiate them from adults.

Accurate diagnosis and treatment are essential to avoid growth problems and permanent functional deficits.