Pediatric and Adolescent Sports Medicine Update

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UCDAVIS MEDICAL CENTER

5/21/17

Shriners Hospitals for Children™ Northern California

Disclosures

None

Course Objectives

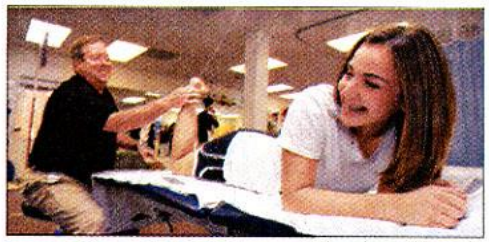
- Review how sports injuries are unique in the pediatric and adolescent population
- Learn updates in the literature regarding surgical management of common pediatric sports injuries
  - Patellar instability / MPFL-R
  - Meniscus repair/Discoid/Meniscus transplant
  - Osteochondritis Dissecans/ Cartilage
  - Tibial eminence avulsion fx/ORIF
  - ACL-R

Pediatric and Adolescent Sports Medicine

- Hot Area of Interest
- Multiple National Medical Organizations with Peds Sports Initiatives & Subcommittees
  - POSNA
  - AOSSM
  - AAOS
  - American Academy of Pediatrics
  - American College of Sports Medicine
- Increasing awareness and interest in the community
  - Lay Press
  - Public

Peds Sports in the Lay Press

San Francisco Chronicle



LANCE IVERSEN / The Chronicle

Nicole Simon, 15, gets physical therapy from Bruce Valentine at Children's Hospital. She has injured both her knees in sports.

Growing pains: Children's sports injuries get worse

By Erin Allday
CHRONICLE STAFF WRITER

Most perilous sports

The sports with the highest injury rates for children:

FOR GIRLS
- Soccer
- Basketball
- Gymnastics

FOR BOYS
- Ice hockey
- Football
- Soccer

Source: Dr. Dennis Caine, Clinics in Sports Medicine

Nicole Simon was 13 when she injured her knee the first time, playing soccer in a competitive girls league.

She was 15 when she injured the other knee — less than one minute into her first basketball game after recovering from the earlier injury — and ended her athletic career before it had ever really started.

"My whole life revolved around sports, and then it was over," said the Piedmont girl, who is going through her second round of rehabilitation at the Sports Medicine Center for Young Adults at Oakland Children's Hospital. "I guess I'll focus on other things now, like school. I'm trying to make the best of it."

Pediatricians and sports medicine experts say that cases like Nicole's have become depressingly common in young athletes. The topic of pediatric sports injuries — from strains and sprains to tendon tears and fractures that need surgery to repair — is a focus of the American Academy of Orthopaedic Surgeons,

▶ **INJURIES:** *Page A10*

The New York Times

A Big-Time Injury Striking Little Players' Knees

Torn Ligament Poses a Greater Risk for Growing Bones

By GINA KOLATA

Last year, when Collin Link was 11 years old, he was tackled as he went in for a touchdown in pee-wee football.

"He didn't get up," his mother, Crystal Link, said. "He kept saying his knee hurt real bad." But Mrs. Link was not overly concerned, thinking it was just a sprain.

But the next morning when the family was getting ready to go to church near their home in The Woodlands, Tex., Collin said he could not walk. That Monday, a doctor told the Links what was wrong.

MICHAEL STRAVATO FOR THE NEW YORK TIMES

Collin Link wears a brace on the knee he hurt last year.

Collin had an injury that doctors used to think almost never occurred in children. He had torn the anterior cruciate ligament, or A.C.L., in his left knee, the main ligament that stabilizes the joint.

The standard and effective treatment for such an injury in adults is surgery. But the operation poses a greater risk for children and adolescents who have not finished growing because it involves drilling into a growth plate, an area of still-developing tissue at the end of the leg bone.

Although there are no complete or official numbers, orthopedists at leading medical centers estimate that several thousand children and young adolescents are getting A.C.L. tears each year, with the number being diagnosed soaring recently. Some centers that used to see only a few such cases a year are now seeing several each week.

And contrary to the old belief that boys are more prone to the injury than girls, as many as eight times more girls than boys are suffering the tears, doctors report.

It is not an overuse injury from playing one sport too intensively, like shoulder injuries in young pitchers. Instead, doctors say, the injury occurs simply from twisting the knee, and diagnoses are on the rise partly because it can now be easily detected and partly because the very nature of youth sports has changed.

In the old days, said Dr. Theodore J. Ganley, director of sports medicine at the Children's Hospital of Philadelphia and a spokesman for the American Academy of Orthopedic Medicine, a child would develop a "trick knee" that made sports difficult, but the real reason was not understood. And most doctors, thinking children did not get A.C.L. tears, did not suspect the real reason.

Now that almost every child with a hurt knee gets a magnetic resonance imaging, doctors are finding the ligament tears on a regular basis.

The other reason for the reported surge in A.C.L. tears, doctors speculate, is that the best athletes are more or less constantly at risk. They play year-round and on multiple teams with frequent games, in which the risk of injury is higher than in practice because of the intensity of play.

"The kids are playing at really highly competitive levels at earlier and earlier ages," said Dr. Mininder S. Kocher, the associate director of the division of sports medicine at Children's Hospital in Boston.

Whatever the reason, the increase in diagnoses has created a new problem: what to do about

Continued on Page A10

Peds Sports in the Lay Press

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Torn ACLs, other big injuries hit little athletes

Posted 7/8/2008 7:35 PM | Comments 10 | Recommend 3

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Enlarge Family handout via AP

In 2006, McCall Maddox of Jacksboro, Texas, tore his ACL during Pee Wee Football at age 12. After an experimental surgery, here he is (No. 6) playing in September 2007.

By Lauran Neergaard, Associated Press

WASHINGTON — A 14-year-old gymnast with a stress fracture in her lower back. A 12-year-old who tore his ACL in a soccer game. A 16-year-old runner with a leg stress fracture. A 15-year-old who tore his meniscus playing basketball.

A single morning's patients for Harvard's Dr. Mininder Kocher provides a window into a troubling trend: Injuries once seen mostly in adult athletes are becoming distressingly common in youth athletes — not just in high school, but in Little League and Pee Wee Football.

These aren't simple injuries. In the past decade, "Tommy John" surgeries to repair elbows blown out playing baseball — an operation named for a Hall of Famer — have almost tripled among adolescents at a high-profile Alabama clinic, a meeting of sports medicine specialists will be told by researchers this week.

PITCHERS: Some as young as 12 treated for serious arm injuries
HEALTH BLOG: More sports medicine news

Worse, some injuries don't have good treatments for young patients. The surgery that fixed the torn ACL in Tiger Woods' knee, for instance, can thwart the growth of a young child's leg.

Kocher, an orthopedic surgeon at Children's Hospital Boston, is about to begin a government-funded study to figure out the best treatment for children who tear that anterior cruciate ligament while growth plates around the knee still are active.

But no matter how well certain injuries heal for now, Kocher worries about the longterm consequences for little joints.

"I wonder what these kids are going to be like 20 to 30 years

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No. 7-10: Diabetes drug risks, placebo effect

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The Boston Globe

Teens training too hard, too often

Athletes' injuries concern doctors

Amanda Keane, 17, of Wilmington, worked on balancing during therapy at Proex Physical Therapy in Woburn last week. (Yoon S. Byun/ Globe Staff)

By Kay Lazar
Globe Staff / June 1, 2010

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Amanda Keane breathes basketball. The Wilmington 17-year-old has been competing four seasons a year since the fifth grade, and has had hip surgery for an overuse injury to prove it.

Peds Sports in the Lay Press

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Posted: Tuesday April 7, 2009 2:45PM; Updated: Wednesday April 8, 2009 9:17AM

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America's Obsession with Youth Sports and How It Harms Our Kids

Story Highlights

- The number of young athletes with injuries from overuse is on the rise
- One doctor sees overworked pitchers ushered into her waiting room at age eight
- Overly competitive parents and coaches are a major reason for such injuries

By Mark Hyman

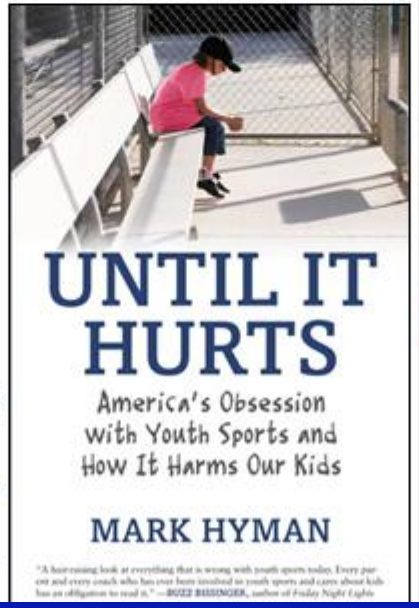
Reprinted from Until It Hurts: America's Obsession with Youth Sports and How It Harms Our Kids, *by Mark Hyman. Copyright © 2009 by Mark Hyman. By permission of Beacon Press, www.beacon.org.*

* * *

Even 27 years after playing his last Little League game, **Patrick Grady** still can't forgive coaches and league officials for what they took from him.

At the time, Grady was 12 years old and playing Little League baseball in Westchester County, New York. By his account he was one of the league's star pitchers, striking out most of the batters he faced and winning almost all the games he pitched. His coaches were impressed. They pitched him constantly. During his two Little League seasons Grady estimates that he was his team's pitcher in two-thirds of its games. There are Little League rules to prevent such abuse. But as Grady recalls, his coaches disregarded them, and league officials didn't object.

Even when Grady's arm began to show alarming signs of overuse, grownups failed to step in. First his elbow ached. Then he began to lose feeling in his pinkie and ring fingers. Through it all he kept pitching. During an all-star game featuring the most talented players from the local league, Grady was the pitcher and ended his coach



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- Texas A&M notifies Big 12 it plans to leave league
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Sharp Rise in Serious Sports Injuries in Children

Tom Brady Fan Sheds Light on Knee Injuries

abc WORLD NEWS WITH DIANE SAWYER

By LARA SALAHI (@LaraSalahiABC) , BRINDA ADHIKARI, and MARK ABDELMALEK, M.D.
Nov. 15, 2011

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Ask Caleb Seymour, 8, of Holden, Maine, to name all the New England Patriot NFL players, and chances are he'll spout them out one by one. Caleb channels the players through his love of all things Patriots and all things football.

But perhaps nothing put Caleb more in sync with the football

Epidemiology

- Youth Sports Injuries
  - More than 3.5 million children ages 14 and under receive medical treatment for sports injuries each year.
  - Children ages 5 to 14 account for nearly 40 percent of all sports-related injuries treated in hospital emergency departments.
  - In 2004, nearly 400,000 children ages 5 to 14 years were treated in emergency rooms for either football or basketball-related injuries.

Epidemiology

Athletes ages 5 to 14 years, injured while playing sports:

Football:	28%
Baseball:	25%
Soccer:	22%
Basketball:	15%
Softball:	12%

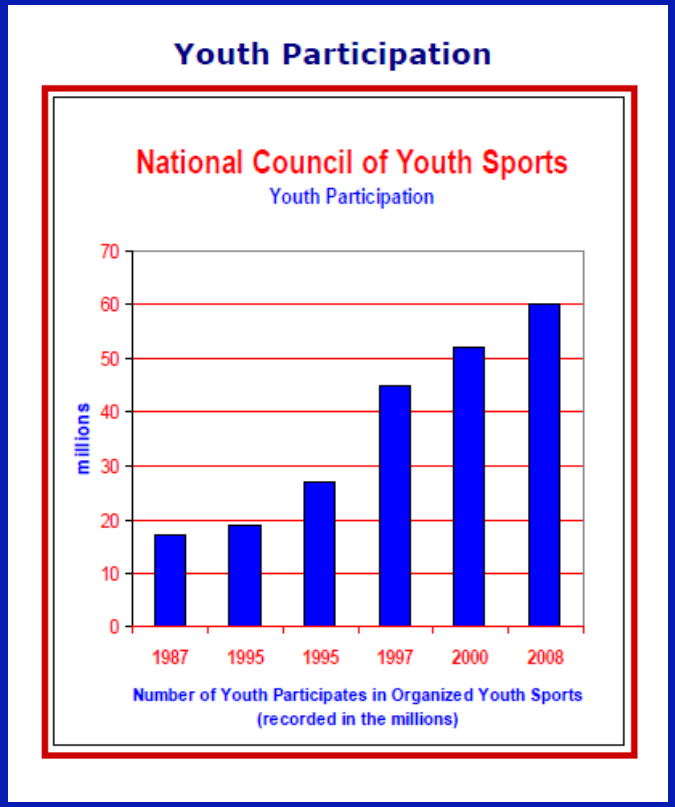
In 2000, sports injuries to children aged 0-14 cost US public $50 billion[1]

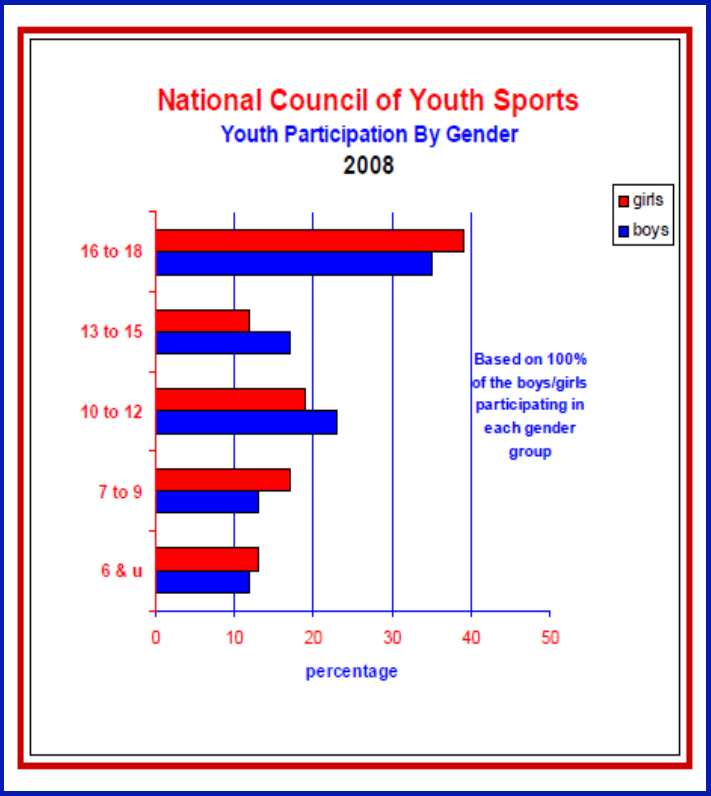
1. U.S. Consumer Product and Safety Commission

Report on Trends and Participation In Organized Youth Sports

NCYS National Council of YOUTH SPORTS

>60 million children and adolescents participate in youth sports in US.





Increases in injury

Knee: (Childrens Hospital Philadelphia)

Age 12 and under

From 1999 to 2011

->400% increase in pediatric ACL injuries

-121 tibial spine fractures

-914 ACL tears

-996 medial meniscus tears

Lawrence,JT, American Academy of Pediatrics National Conference, 2011

Increases in injury

Elbow:

UCL tear >500% increase in prevalence of UCL tears and need for "Tommy John" surgery[1] from 1995-2005

1. James Andrews, Little League Pitch Count Regulation Guide, American Sports Medicine Institute.

Prevention: CDC

CDC Home

Centers for Disease Control and Prevention

CDC 24/7: Saving Lives. Protecting People. Saving Money through Prevention.

SEARCH

A-Z Index A B C D E F G H I J K L M N O P Q R S T U V W X Y Z #

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- Road Traffic Injuries
- Sports Injuries
- About the Initiative

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- Event Planning Guide
- Order Free Materials
- Child Injury Prevention

Injury Center > Safe Child Home

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SPORTS INJURIES

Sports Injuries: The Reality

We all want to keep our children safe and secure and help them live to their full potential. Knowing how to prevent injuries from sports and recreation activities, one of the leading causes of child injury, is a step toward this goal. Taking part in sports and recreation activities is an important part of a healthy, physically active lifestyle for kids. But injuries can, and do, occur. More than half of the 7 million sports and recreation-related injuries that occur each year are sustained by youth between ages 5 and 24. Thankfully, there are steps that parents can take to help make sure kids stay safe on the field, the court, or wherever they play or participate in sports and recreation activities.

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Prevention Tips

Gear up. When children play active sports, make sure they use protective gear, such as helmets, wrist guards and knee and elbow pads—in addition to any other sports gear appropriate to their activity or player position. Further, during informal recreation activities children should also always

Peds Sports in the CA Assembly

Tuesday, November 15, 2011

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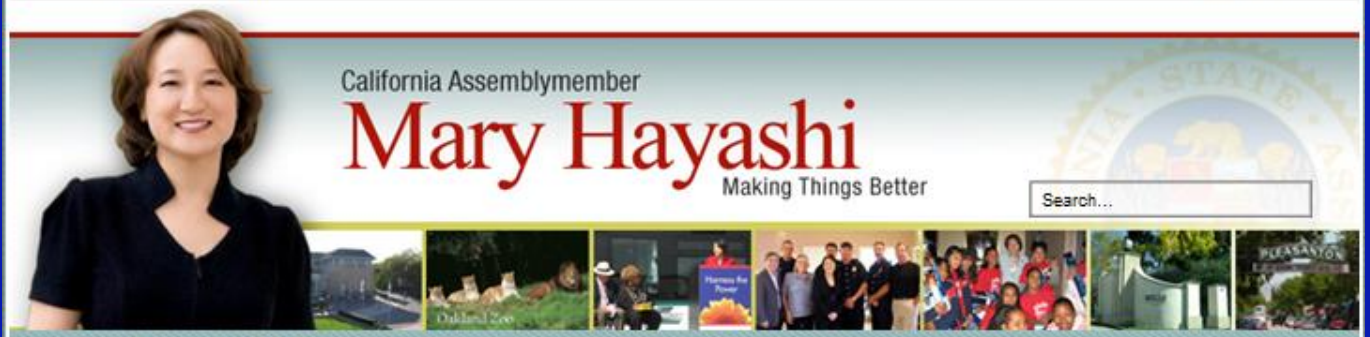

California Assemblymember

Mary Hayashi

Making Things Better

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Wednesday, September 07 2011

NFL Supports California on Passage of Assembly Bill 25, Aimed at Protecting Young Athletes

Featured

The NFL commends California, whose legislature passed Assembly Bill 25 today. The bill, which now moves to the governor's office, protects young athletes and fosters head injury awareness in youth sports.

The bill contains three core components: 1) a youth athlete suspected of suffering a concussion in school sports cannot return to play that same day; 2) once removed from play, an after-school youth athlete cannot return to play until they have been evaluated and cleared to play by a licensed medical professional; and 3) parents must complete an education form prior to their child participating in the youth sports activity.

Assembly Bill 25 was authored by Assemblywoman Mary Hayashi and Senator Tony Strickland and is strongly supported by the NFL, Oakland Raiders, San Diego Chargers, San Francisco 49ers, educators, youth sports organizations and health professionals. It was co-sponsored by Senate President pro tem Darrell Steinberg, Assembly Speaker John A. Pérez and Senator Alex Padilla

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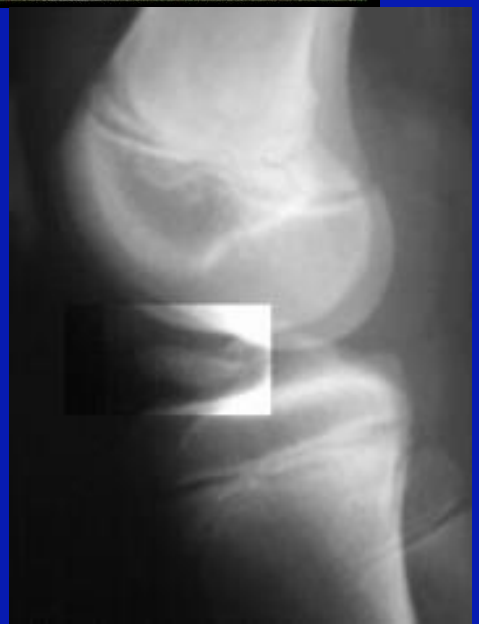
Sport Concussion

Why?

- Early sport specialization
- Younger age
- Year-round training
- Greater rate of participation
- Increased level of competition
- Declining fitness levels

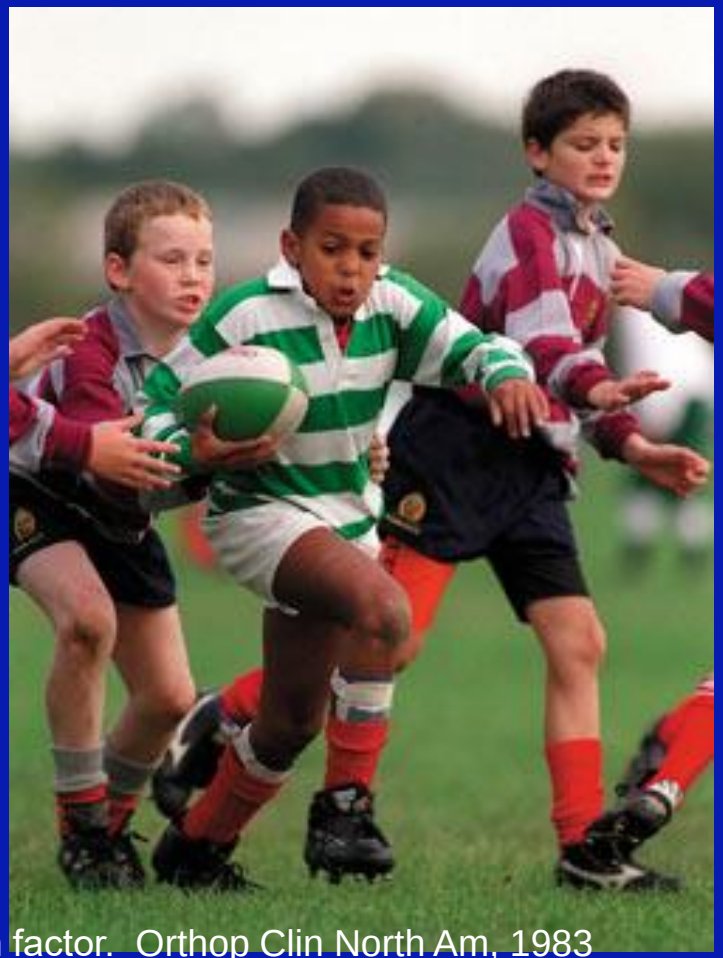
Pediatric Sports Medicine



- Child athlete is **NOT** just a little adult athlete
- Injuries and operative interventions to skeletally immature athlete can lead to physeal arrest, limb length inequality and/or angular deformity
- Non-operative treatment until child reaches skeletal maturity is often not practical in today's society

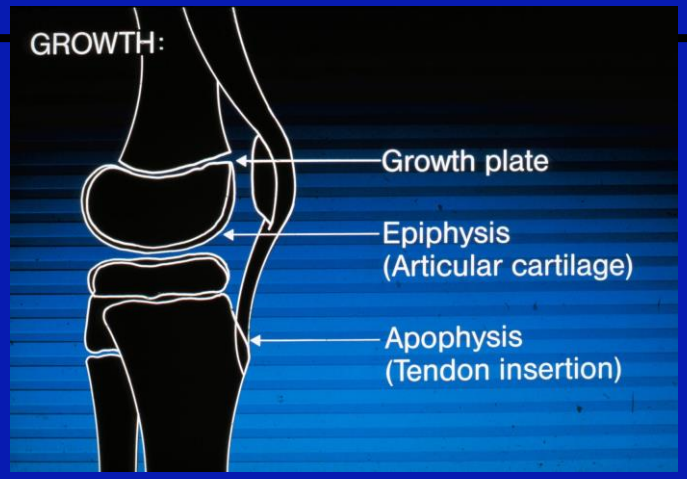
Child = Growth

- Muscle and tendon imbalance[1]
- Increased muscle and tendon tightness[1]
- Decreased physeal strength[2]
- Bone mineralization lags behind linear growth[3]



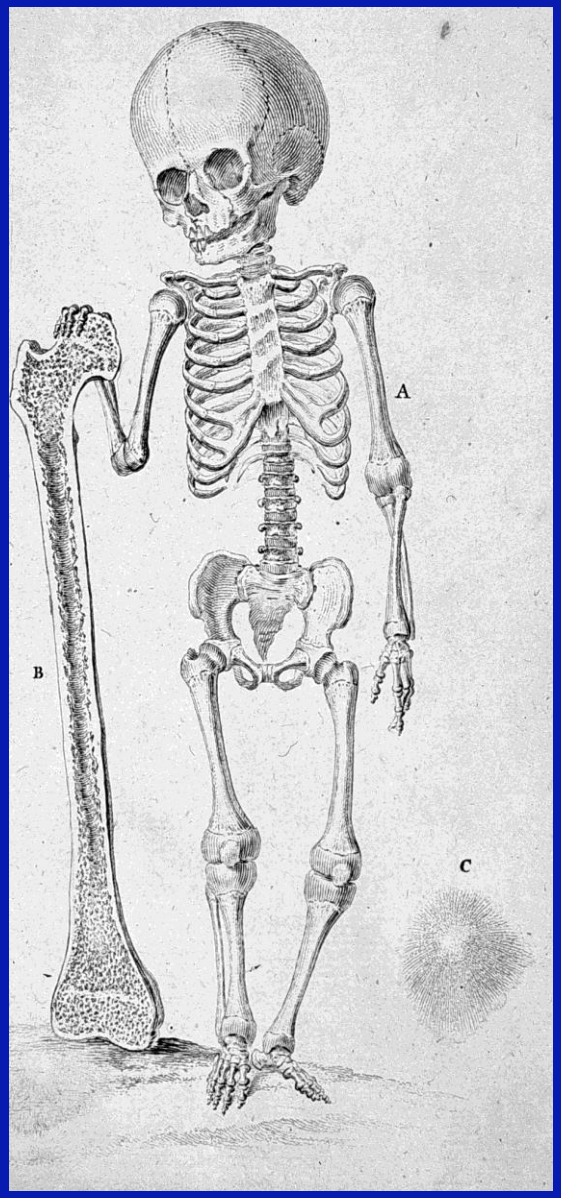
1. Micheli LJ. Overuse injuries in children's sports, the growth factor. Orthop Clin North Am, 1983
2. Bright RW. Epiphyseal-plate cartilage: a biomechanical model of failure. JBJS, 1974.
3. Peterson CA. Analysis of injuries to the epiphyseal growth plate. J trauma, 1972.

Growth Cartilage: Overuse and Acute Injuries



1. Physis (Epiphysiolysis, Physeal Fx)
2. Apophysis (Apophysitis, Avulsion Fxs, Tibial Spine Avulsion-ACL)
3. Joint Surface (Osteochondral Fx, Osteochondritis Dissecans)
4. Ligamentous (ACL, meniscus)

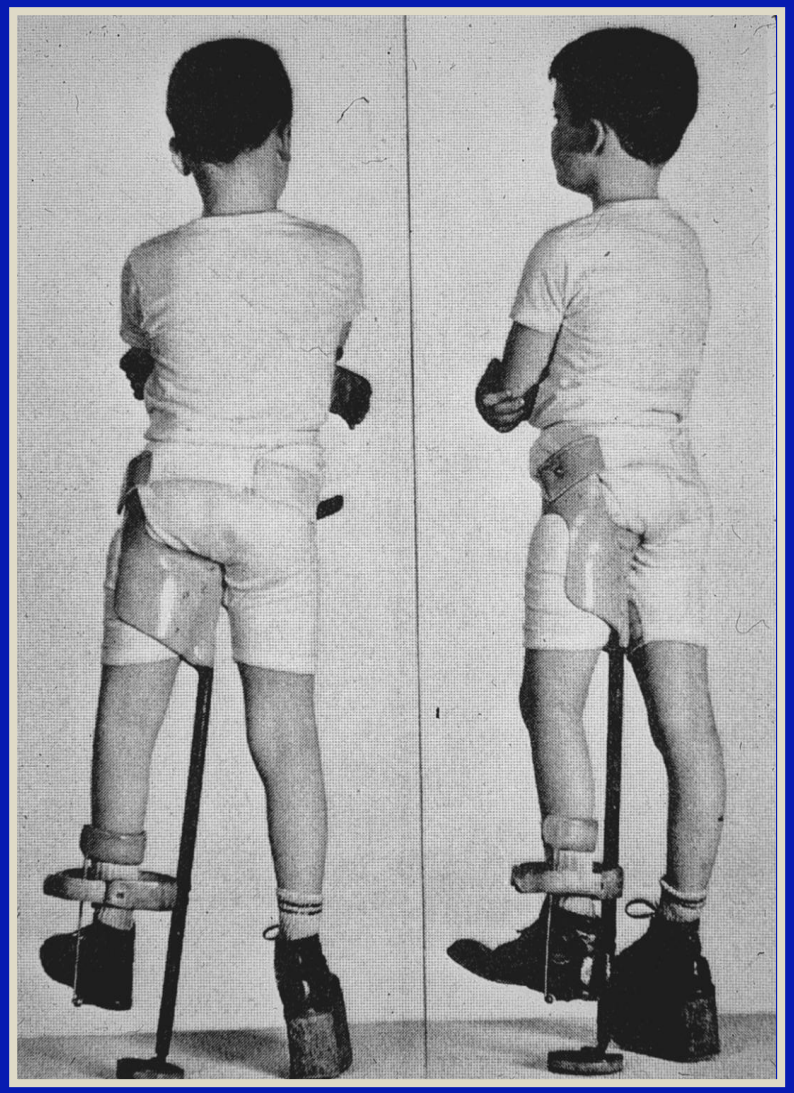
Pediatric Knee Injuries



- Patellofemoral Instability
- Meniscal Tears
  - Discoid Lateral Meniscus
- Cartilage Injury
  - Osteochondritis Dissecans
- Fractures
  - Tibial Spine Fx
- Ligament Injuries
  - ACL Injury
  - ACL Repair?
- Summary

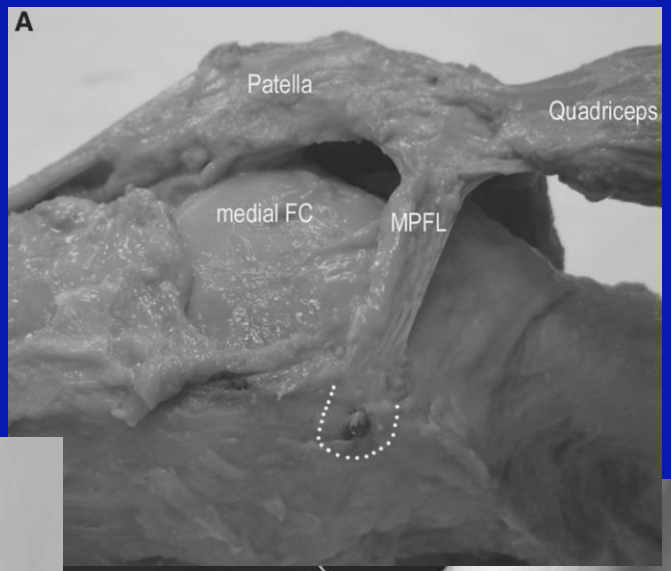
Pediatric Knee Injuries

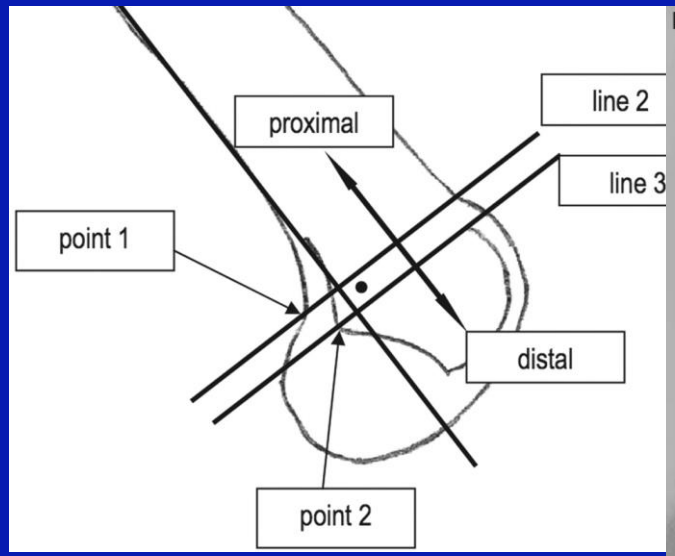
- Change in Approach
  - Cast & Heal
  - Tibial Spine Fx
    - ACL tear rare
  - Physeal Fx
    - MCL sprain rare
  - Juvenile OCD heals
  - Meniscal Injuries rare
  - Treat patellofemoral instability conservatively

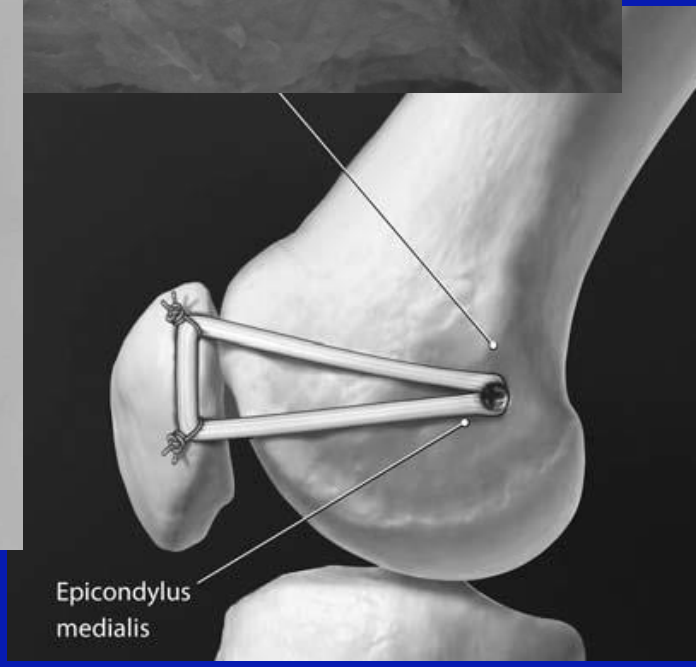


Adult Patellofemoral instability

- MPFL reconstruction
- Schottle's point
- Tibial tubercle osteotomy



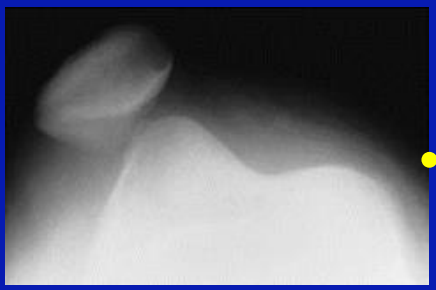




Schottle, AJSM, 2008
Schottle, Arch Orthop Trauma Surg 2008

Patellofemoral Instability

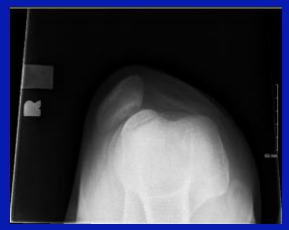
1st time dislocator



- Obtain MRI to rule out osteochondral fracture (16%), if none then:
  - Protective bracing/PT for 6-12 weeks
  - Return to sports in 8-12 weeks
- No functional difference between operative and non-op[1]
- RCT: Subjective result excellent[2]
  - 75% non-op, 68% operative (repair of MPFL)
- RCT: Recurrence[2]
  - 71% non-op, 67% operative (repair of MPFL)

1. *Apostolovic Int Orthop 2011*
2. *Palmu JBJS, 2008*

Pediatric Recurent Patellar Instability



Risk factors/Treatment

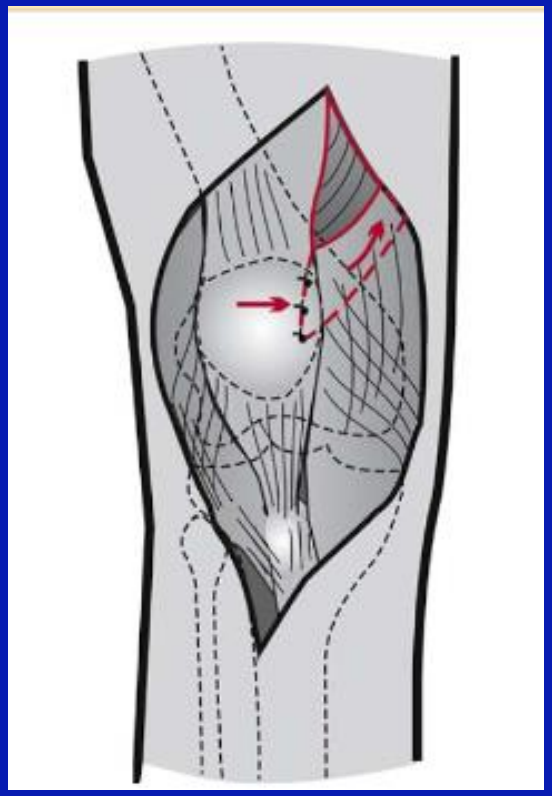
Proximal

1. Ligamentous laxity/MPFL tear –
   Medial plication/MPFL-R or Insall
2. Patella Alta – PT – Wait for maturity for TTO
3. Trochlear dysplasia – Trocheoplasty?
4. Genu valgum - Guided growth
5. Femoral anteversion – Femoral DRO

Distal

1. External tibial torsion – Tibial DRO
2. Increased TT-TG – Roux-Goldthwaite or wait TTO
3. Proximal tibial varus- Guided growth

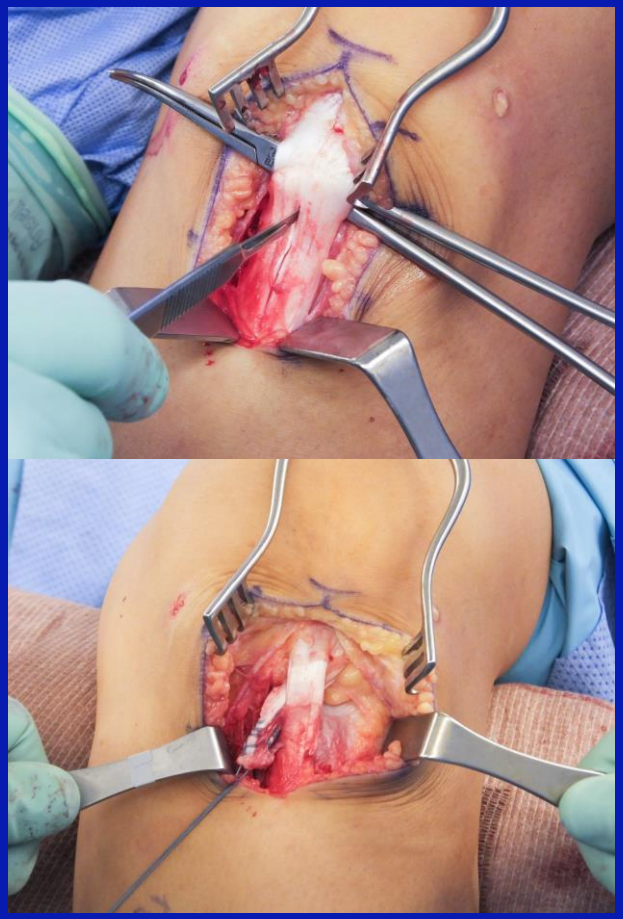
Proximal Realignment



Insall Procedure

- Distalization of vastus medialis insertion onto patella
- Good short term success (92%)
- Limited studies on longterm risk of OA
- Nonanatomic

Distal realignment in skeletally immature



Roux-Goldthwait

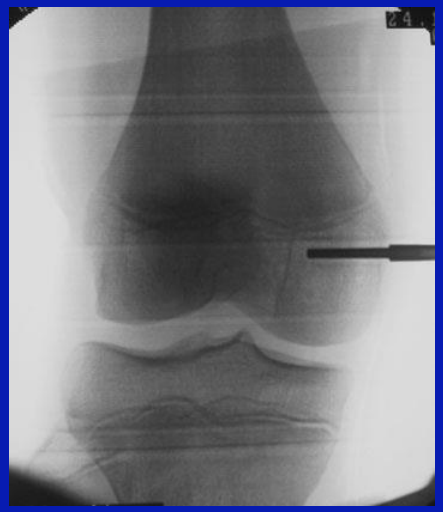
Splits patellar tendon, elevates off insertion, transfers half medially

- Nonanatomic
- High rate of failure?
- Extension weakness?
- Does tendon heal to bone?
- Or does it degrade?

MPFLR in Skeletally Immature

- MPFL insertion variable, most insert on or distal to physis in skeletally immature[1,2]
- MPFL placed proximal to physis will tension with growth as child grows (moves up the leg)
- AP and lateral views will show different relationship of physis to insertion[3]

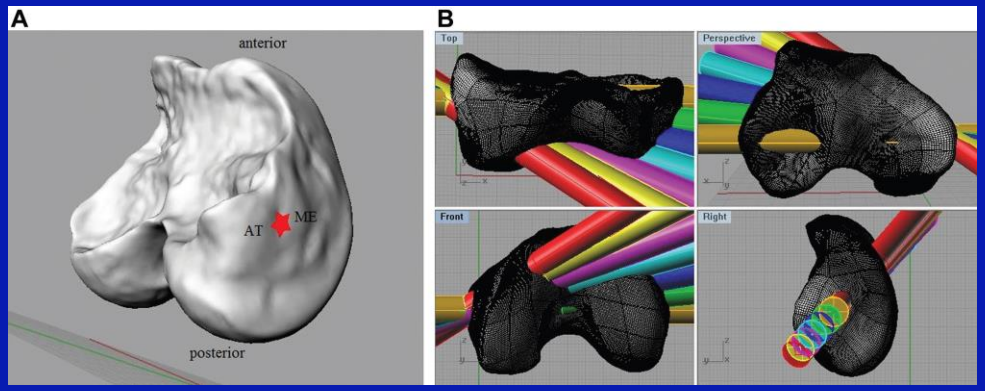





1. Shea, Arthroscopy 2010, 2. Shea, AJSM 2016, 3.Nelitz/Lippacher AJSM 2013

MPFLR in Skeletally Immature

- Drill femoral tunnel distal and anterior
- Success rate:
- Include growth modulation
  - Anatomic study shows safest in preventing injury to physis[1] (& peroneal nerve!)
  - Check Notch view to prevent ACL/PCL injury
  - Include growth modulation thru same incision

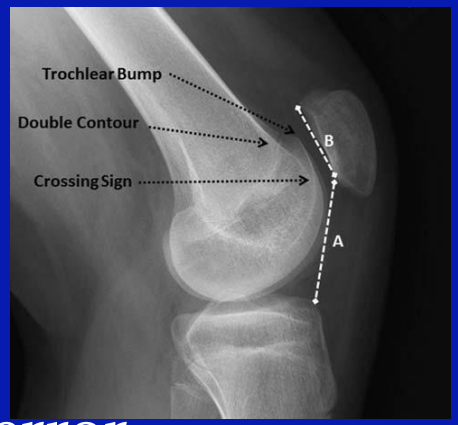


1. Nguyen, AJSM, 2017.

MPFLR in Skeletally Immature

- RCT Non-op vs MPFL[1] – 2yr

Non-op	MPFL
Kujala score - 70.8	Kujala score – 88.9
Good/excellent –25%	Good/excellent – 71%
Recurrent – 33%	Recurrence – 0%

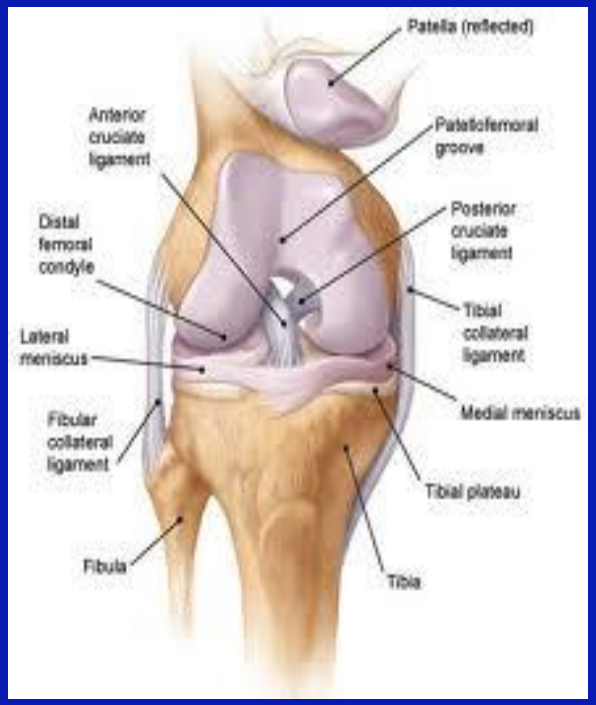


- Insall vs MPFL vs control[2]
  - Insall had increased joint reaction forces
  - MPFL = control
- Complications (16%)[3] – 47% due to technical error
  - Recurrence (4%), Stiffness (4%), patellar fractures (3%), arthrosis (3%)
  - Posterior growth arrest and flexion contracture[4]

1. Bitar, AJSM, 2012.
2. Edmonds, JPO, 2016.
3. Parikh, AJSM, 2013
4. Sietlinger, Knee, 2017

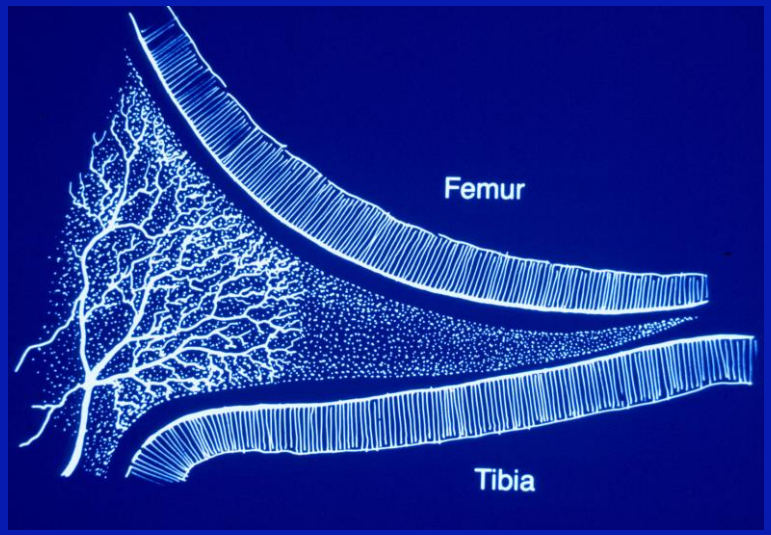
Meniscus Tears in Young Athletes

- 50% patients undergoing complete meniscectomy develop arthritis average of 15 years later (Englund, Arthritis Rheum 2009)
- 60% of children with meniscectomy had poor results 5.5 years later (Manzione, AJSM, 1980)
- 20 years later, 90% had arthritis, 71% had pain, 68% stiffness, 54% swelling (Wroble, CORR 1992)



Meniscus tears

- Vascularity/Cellularity
  - Children have more cells and better vascularity than adults
  - May faciliate better healing potential in young[1]



1.Arnoczky, Microvasculature of Human Meniscus, AJSM, 1982.

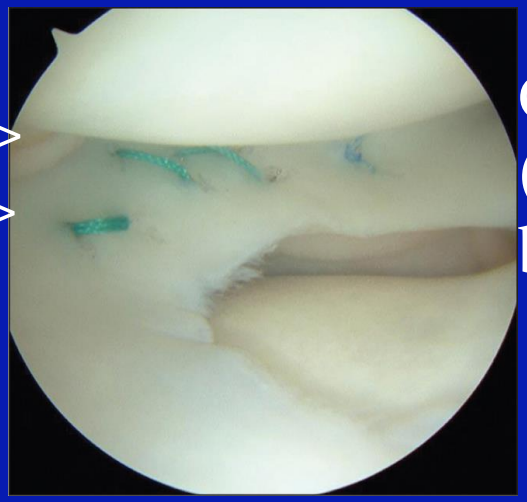
Meniscal Tears in Young Athletes

- Historically considered rare in pediatric and adolescent population
- Increasing incidence (Kramer, JAAOS 2011, Bellisari Sports Med Arthrosc)
- Increased year round sports and improved MRI
  - Meniscal tears in 47% of preadolescents (aged 7 to 12 years) and in 45% of adolescents (aged 13 to 18 years) with acute traumatic knee arthrosis

Meniscal Repair

Adults = Rest/PT, then meniscal debridement if fail
Children/Adolescents = Early meniscal repair, not PT/rest

Lateral meniscus[1] (67%)> medial meniscus (22%) > both (11%)



Complex[1] (28%)>vertical (16%)>discoid(14%)> bucket-handle (14%)

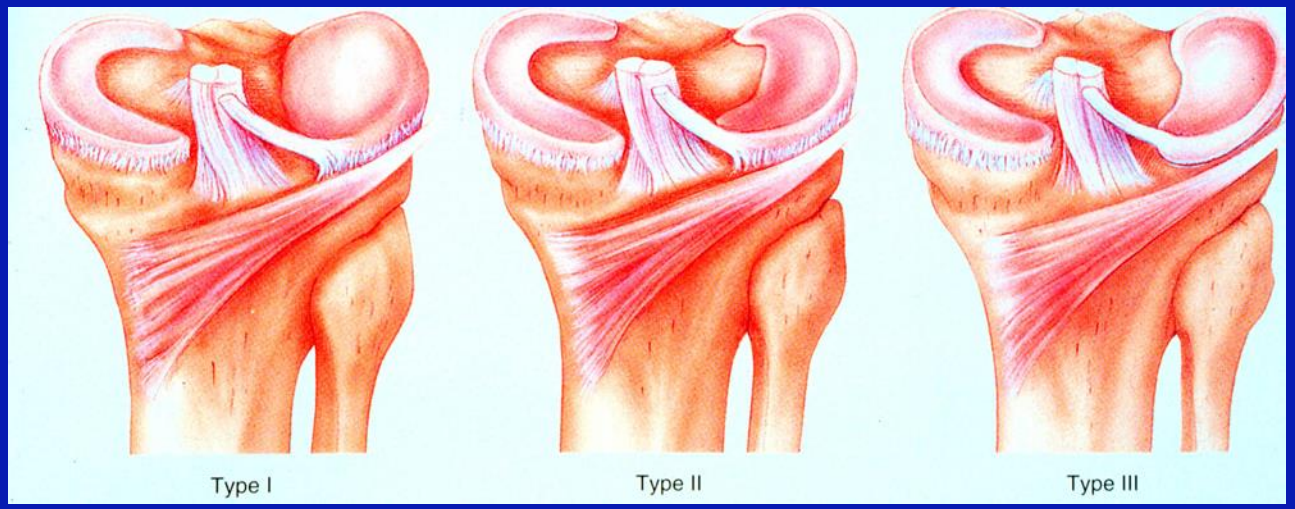
Success rates:
Meniscus repair successful in 82% adolescents
Revision highest with bucket handle tears

1. Shieh A, Edmonds, Pennock AJSM 2013
2. Shieh A, Edmonds, Pennock AJSM 2016

Discoid Lateral Meniscus

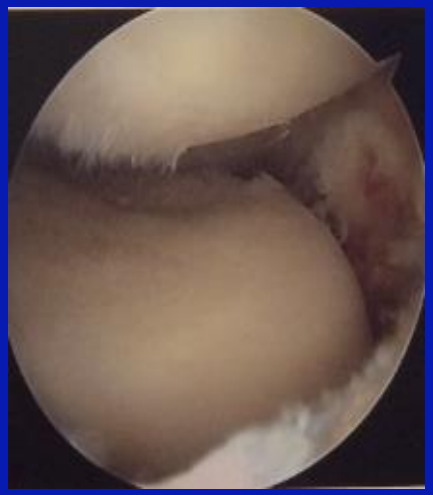
Snapping, Joint Line Tenderness
Locked/ Lack of Extension,

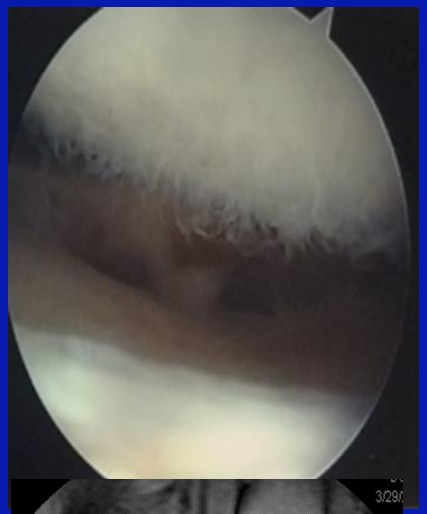
Adolescent: Meniscal Tear
Child: “Snapping Knee”



Discoid Lateral Meniscus

- Treatment
  - Incidental, Asymptomatic
    - Observation
  - Complete Menisectomy:
    - Degenerative Changes
    - 40-45% s/p meniscectomy or partial meniscectomy had a fair or poor clinical rating after an average follow-up of 6.5 years[1,2]
    - After 10 years, degenerative changes seen after 88% complete meniscectomy

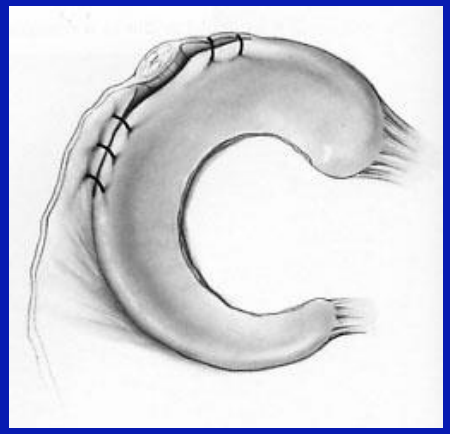


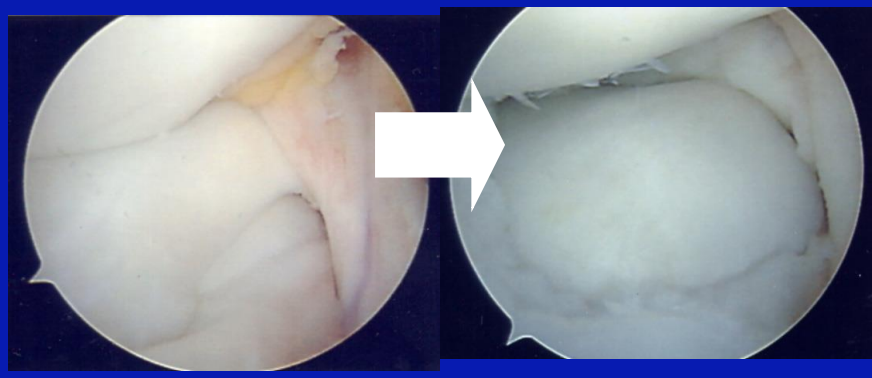


1. Vangness CT, AJKS, 1999.
2. Vandermeer, Arthroscopy 1989.
3. Ahn, Arthroscopy, 2015

Discoid Lateral Meniscus

– Saucerization/Repair/ Stabilization
  - Torn or Symptomatic Discoid Lateral Meniscus
  - Abnormal collagen tissue and meniscocapsular attachments
  - Pre-op Lysholm 46/63, post-op 86/92; younger age + prognostic factor[1,2]





1. Hagino, Arch Ortho Trauma Surg, 2017
2. Kose, Musc Surg, 2015.

Meniscus Allograft Transplant

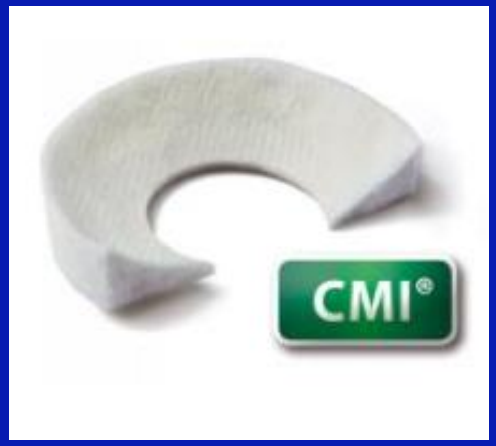
- Articular cartilage degenerates after subtotal/total lateral meniscectomy (4.5 years) but radiographic arthrosis progression is reduced after meniscal transplantation (3.5years)[1]

- No studies on pediatric population

1. *Lee BS. AJSM, 2016.*

Advancements in Meniscus?

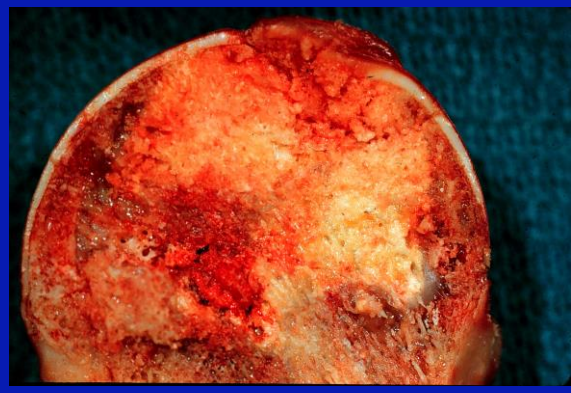
Meniscus Tissue Engineering/ Collagen Meniscus Implant

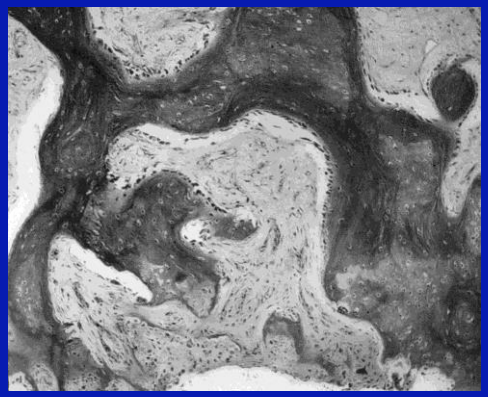


PRP/MSCs

Osteochondritis Dissecans (OCD)

- Etiology
  - Repetitive Trauma (Fairbank/Smillie)
  - Ischemia (Enneking -1980)
  - Ossification Abnormality (Ribbing-1955)
  - Genetic (Petrie -1977)
- Age/Sex
  - 12.9 yrs/male 3:1 (Cahill 1983)
- Bilaterality – (25%-33%)
- Location (Knee: 75%)
- Pain/Swelling/Limp/Catching

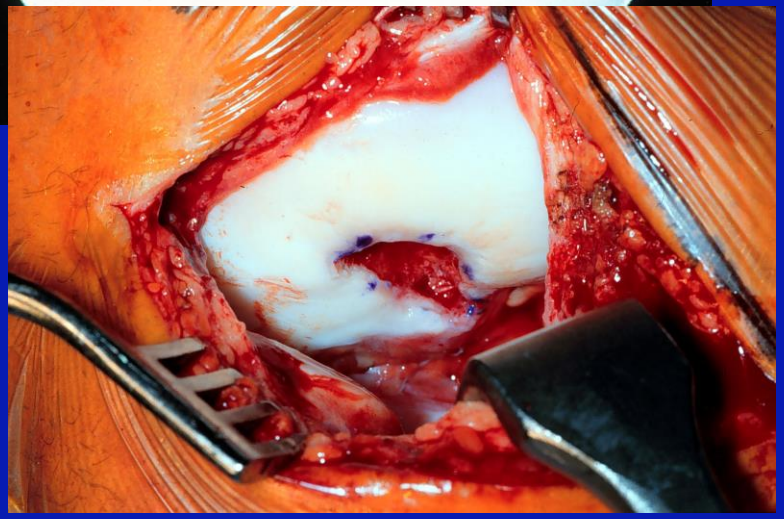




jOCD: Nonoperative Rx

- Initial Management
- Healing Potential
- Treatment:
  - Activity Restriction
  - Protected Weight-Bearing
  - Immobilization
  - Unloader Brace

OCD: Nonoperative Rx



- Problems
  - All Lesions do Not Heal
    - Cahill et al (1989)
      - 43% failure (92 knees in 76 pts)
      - 10-18 months restriction & PWB
  - Length of Treatment
    - 6-24 months
    - Compliance
    - Approach Skeletal Maturity

OCD Classification/Treatment

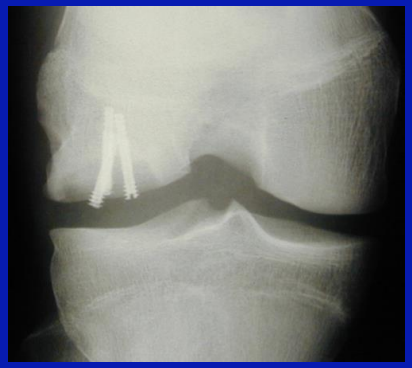
Stage I: Subchondral Compression - Percutaneous Drilling

Stage II/III: Partially Detached/ Detached In-Situ

» ORIF with SmartNails

» Curet and bone graft

Stage IV Free Fragment

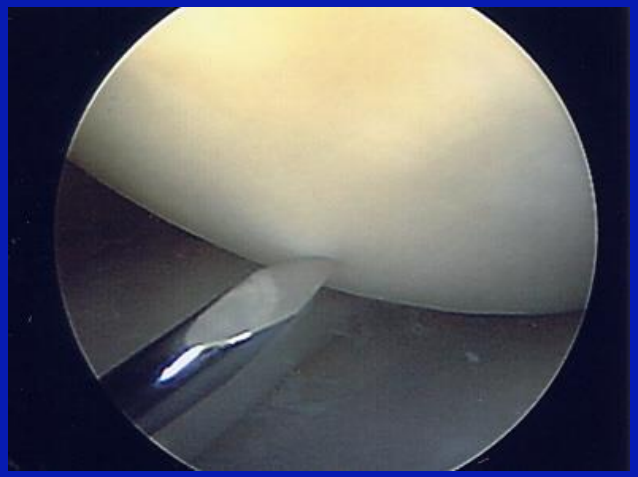


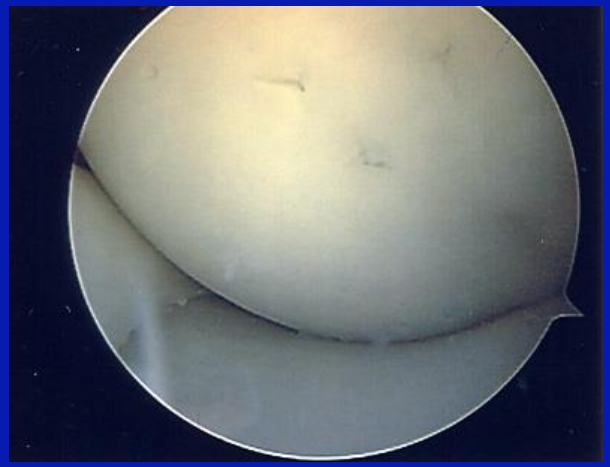
» Removal of loose body, Debride

» Cartilage Biopsy for Autologous Chondrocyte Implantation (ACI)

OCD: Operative Rx

- **Stage I/II: Drilling**
  - Rationale
    - enhance vascularity
  - Indications
    - stable lesion; intact surface
    - concurrent with fixation
  - Approach
    - Retrograde (Transarticular)
    - Antegrade (Epiphyseal)
  - Results: Lysholm score (from 58 to 93). Healing of 4.5mm AP and 8.4 lateral at 4.4 months[1]

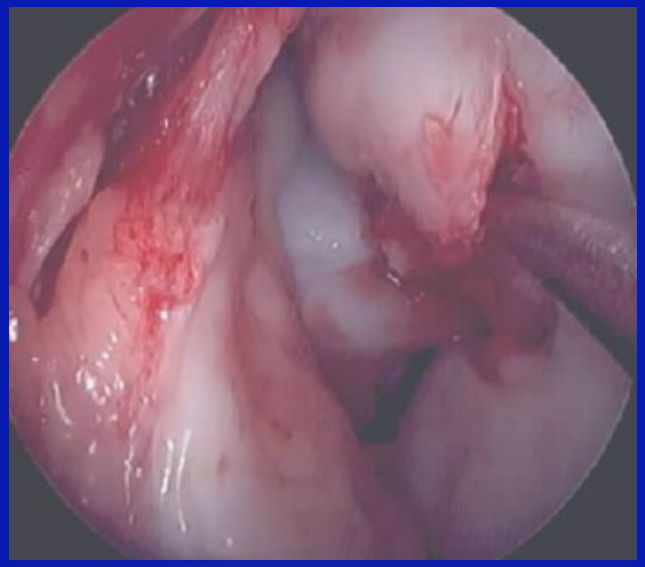


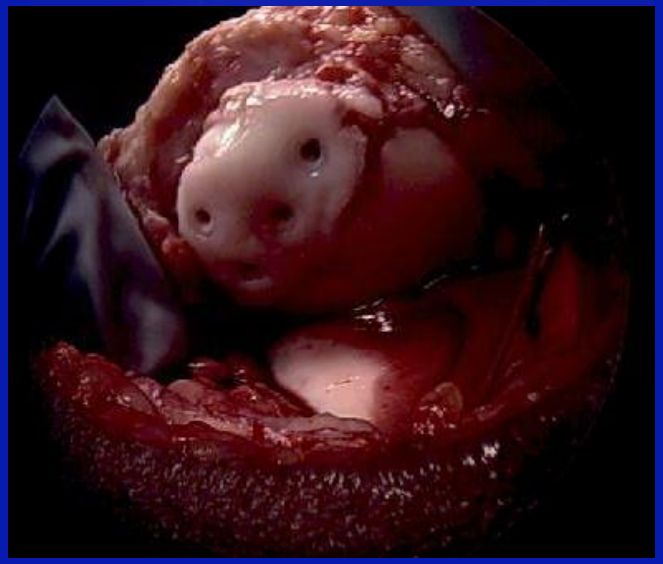


1. Kocher AJSM 2001.

OCD: Operative Rx

- Stage II/III:ORIF/Bone graft
  - Rationale
    - stability
    - fracture healing
  - Indications
    - unstable, detaching
  - Approach
    - retrograde
  - Technique: screws, SmartNails
  - Results: 84% healed at 3yr FU
    - Lysholm 88.0, IKDC 84.0





1. Tabbador, JPO, 2010.

OCD: Operative Tx

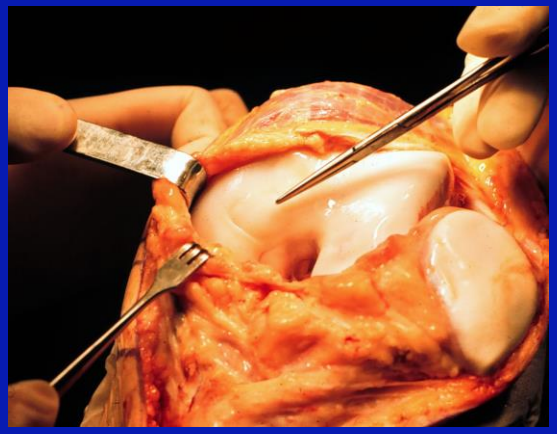
- Excision
  - Rationale
    - simple
    - loose body nonhealing
  - Indications
    - detached lesion/ loose body
    - chronic (mismatch/ avascular)
  - Technique
    - marrow stimulation
  - Prognosis: 45% radiographic changes at 9 years
    - Anderson (*AJSM 1997*)

OCD: Operative Rx

- Chondral Resurfacing:

Recommended Treatment	Lesion Size
Microfracture	1-2.5 cm^2; well-shouldered, protected edges
Osteochondral autograft	1-2.5 cm^2; grafts need to be perpendicular and flush to surface
Autologous chondrocyte implantation	>2 cm^2; background factors need to be addressed, patient must be compliant with rehabilitation
Osteochondral allograft	>4 cm^2; uncontained large lesion involving substantial osseous loss

- Autologous Chondrocyte Implantation (MACI)
  - Minimally invasive
  - 12 year FU improvement[1]– 88.7 KOOS, 94.7 ADL, Cincinnati 7.9



1. . Beck/Micheli, JCO, 2017

Recommended Operative Treatment According to Lesion Size *From:* JONES: JBJS Am 2006

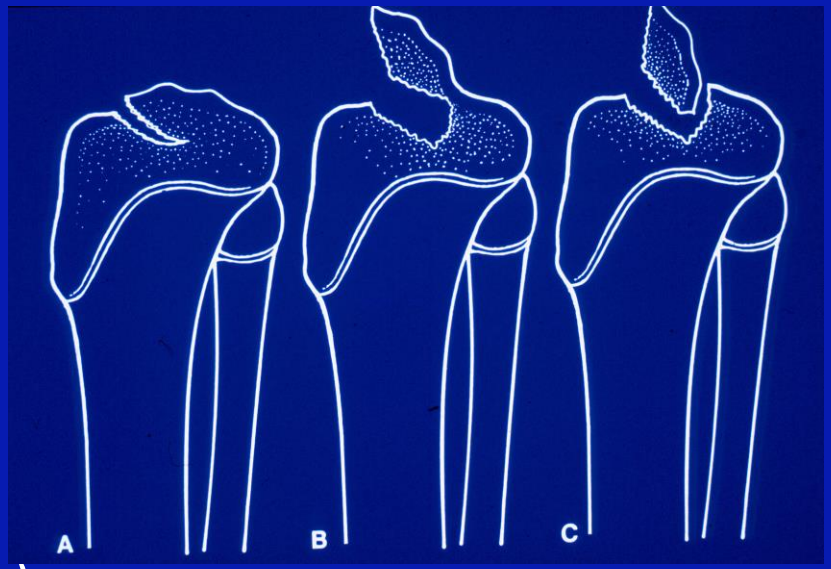
Tibial Spine Fracture

- "Pediatric ACL injury"
- Anatomy
  - ACL attaches to intercondylar eminence
- Etiology
  - relative strength:

    eminence vs ACL

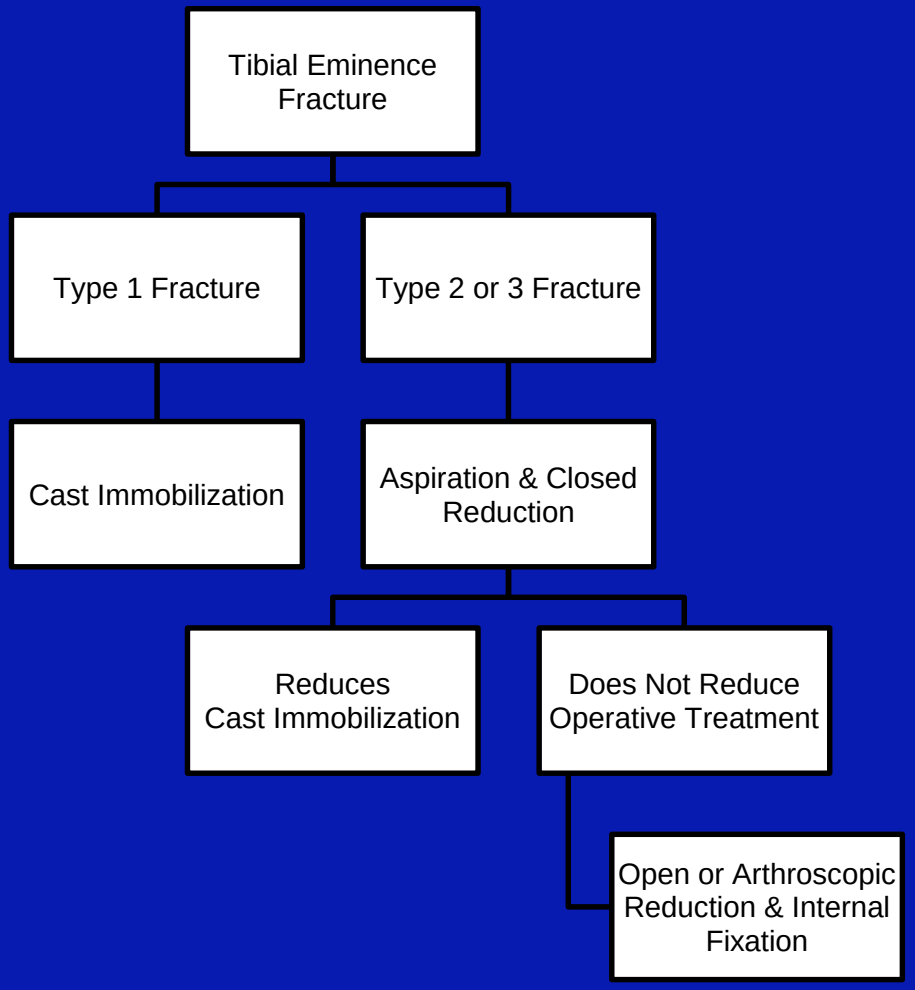
Tibial Spine Fx

- Signs & Symptoms
  - hemarthrosis
  - lack extension (bony block)
  - anterior laxity
- Imaging
  - lateral knee x-ray
- Classification
  - Meyers & McKeever (JBJS, 1959)
    - Type I minimal displacement
    - Type II hinged
    - III completely displaced



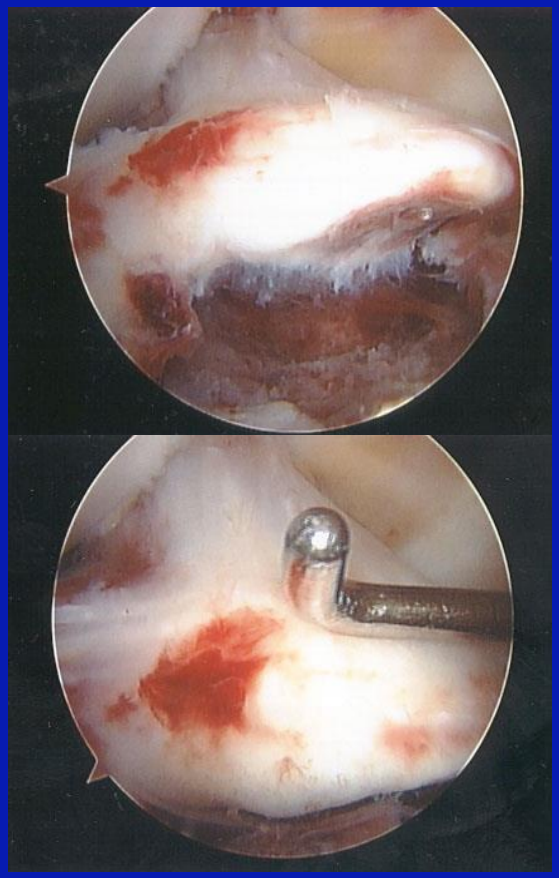
Tibial Spine Fx

- Recommendations 2017:
- Type I Fractures:
  - long-leg cast: extension
- Type II & III Fractures:
  - Aspiration & Reduction
  - Nonreducible: ARIF



Tibial Spine Fx

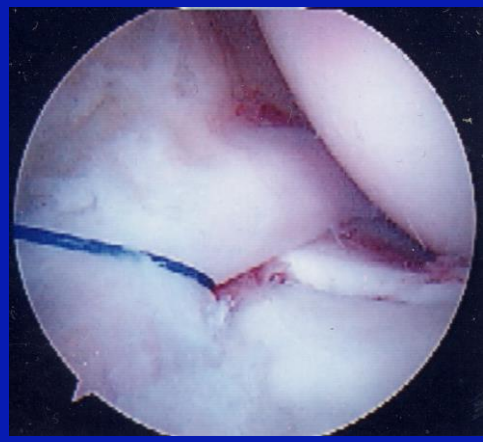
- Displaced Tibial Spine Fracture
  - Operative Treatment Recommended
    - Anatomic Reduction
      - Lack of Extension
      - Instability
    - Early Mobilization
    - Associated Injuries
      - Chondral Injury
      - Meniscal Injury



Tibial Spine Fracture - Meniscal Entrapment

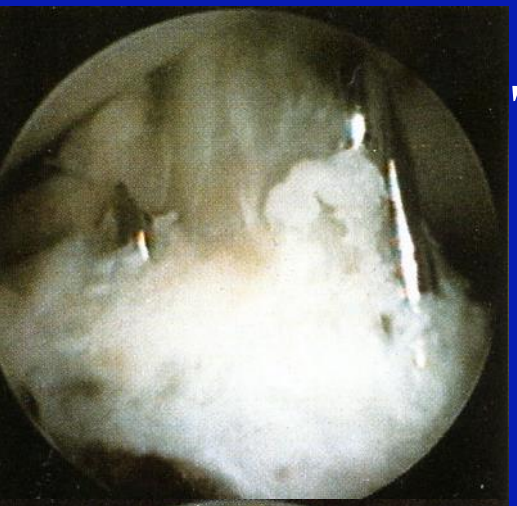
Meniscal entrapment[1,2,]
Type II fx: 26% (6/23)
Type III fx: 65% (37/57)

Anterior horn medial meniscus (83%)
Intermeniscal ligament (14%)
Anterior horn lateral meniscus (3%)



1. Kocher, Tibial Eminence Fractures in Children, AJSM, 2013
2. Feucht, Knee Surg Sports Trauma Arthrosc, 2017.

Tibial Spine Fx



Treatment Options

- Operative
  - –Open Reduction & Internal Fixation
  - –Arthroscopic Reduction & Internal Fixation
    - »Suture vs. Screws vs Endobutton vs SpeedBridge

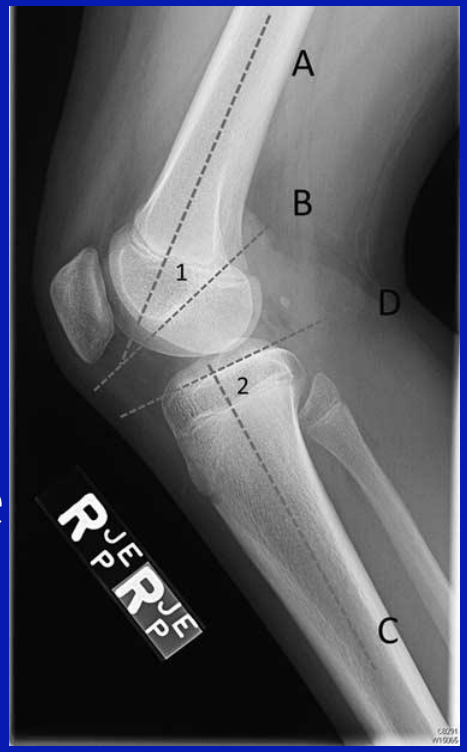
A/ORIF Tibial Spine Fx

- Suture fixation biomechanically stronger than screw fixation[1,2]
- Absorbable outcomes = nonabsorb suture[2]
- No consensus as to best method in 2017
- Complications:
  - Arthrofibrosis (10-30%)
    - Physeal fracture during MUA
  - Laxity (5mm)
  - Nonunion rare (meniscal entrapment)

1.*Senekovic, Arthroscopy, 2014*
2. *Sawyer, Arthroscopy, 2012.*
3. *Liao, Arthroscopy, 2016*

ACL Tear

- Increased Prevalence
  - Previously consided rare, 490%
  - Increased participation, competitive level, younger age
  - Increased awareness & arthroscopy
  - Intercondylar roof inclination angle (RIA)
    - Steeper (lower) RIA → ACL tear
    - Flat (higher) RIA → Tibial eminence fx



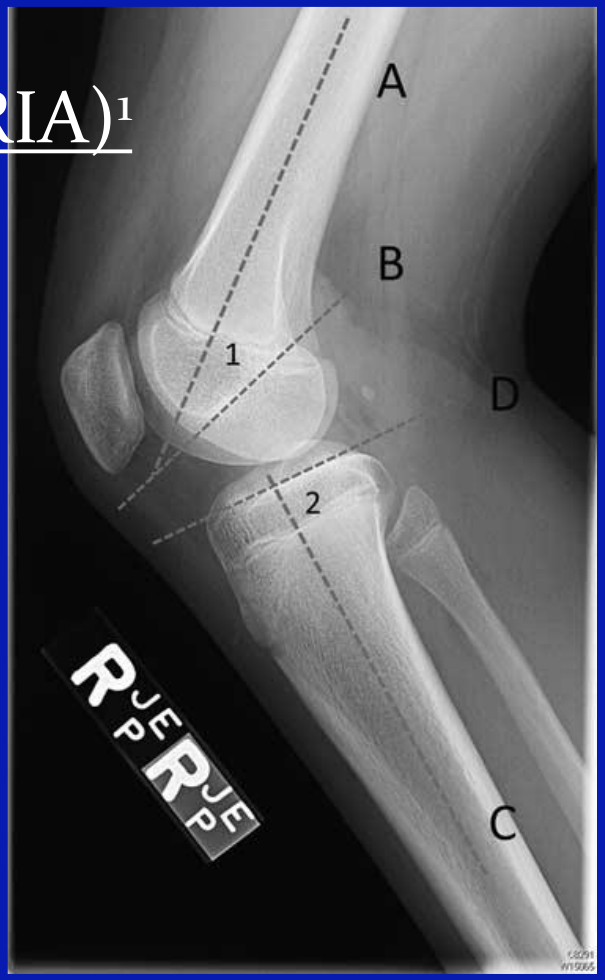
ACL Tears

- Increased Prevalence
  - Previously considered rare
  - 490% increase over last 15 years
  - Increased participation, competitive level, younger age
  - Increased awareness & arthroscopy
  - Recent studies show increase:
    - 3:1 ratio in ACL: tibial eminence fx in pre-pubescent
    - 25:1 in closing growth plates

ACL Injuries

Intercondylar roof inclination angle (RIA)[1]

- Steeper (lower) RIA →
  ACL tear
- Flat (higher) RIA →
  Tibial eminence fx



1. Samora, JPO, 2016

Controversy: Pediatric ACL Injuries

- Initial Management
  - Nonoperative vs Operative
- Operative Management
  - Technique
    - Nontransphyseal
    - Partial Transphyseal
    - Transphyseal
  - Graft Choice / Fixation
  - Age / Skeletal Maturity
- Complications
  - Growth Disturbance

Complete ACL Tears – Non-op Outcomes

THE CONSERVATIVE TREATMENT OF COMPLETE TEARS OF THE ANTERIOR CRUCIATE LIGAMENT IN SKELETALLY IMMATURE PATIENTS

J Bone Joint Surg [Br] 1995;77-B:890-4.
Received 27 September 1994; Accepted after

HIROSHI MIZUTA, KENJI KUBOTA, MINORU SHIRAISHI, YUTAKA OTSUKA, NORIYOSHI NAGAMOTO, KATSUMASA TAKAGI

1/18 return to preinjury sport level

6/18 meniscal tears

11/18 had radiographic evidence of degenerative changes at 36 months

Complete ACL Tears – Non-op Outcomes

- Prognosis of Nonoperative Management (complete tears):
  - McCarroll et al (*AJSM* 1988)
    - »3/16 return to preinjury sport, 4/16 meniscal tears

Complete ACL Tears – Non-op Outcomes

Associated Injuries in Pediatric and Adolescent Anterior Cruciate Ligament Tears: Does a Delay in Treatment Increase the Risk of Meniscal Tear?

Peter J. Millett, M.D., M.Sc., Andrew A. Willis, M.D., and Russell F. Warren, M.D.

Acute(<6 weeks) vs Chronic (>6 weeks) Treatment of ACL Tears

Medial meniscus tears significantly more common (p=0.02) in chronic group (36%) than acute group (11%)

Lateral meniscus tears seen at equal frequency

Complete ACL Tears – Non-op Outcomes

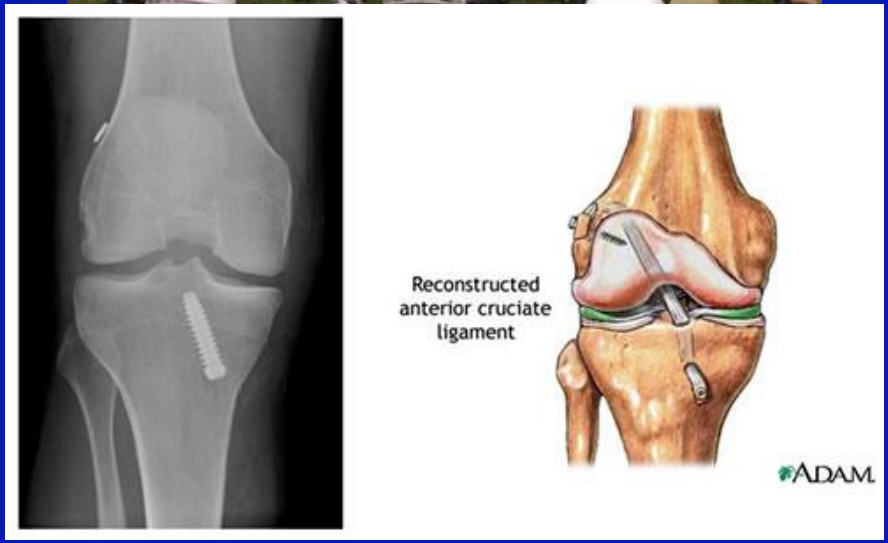
- Prognosis of Nonoperative Management (complete tears):

  60 to 90% of ACL-deficient subjects exhibit osteoarthritic changes on X-ray within 14 years (*Ann Rheum Dis* 2004)

ACL Reconstruction

Problems:

- Adult surgery on open physis
  - Growth Remaining
    - Chronological Age
    - Skeletal Age
    - Physiological Age



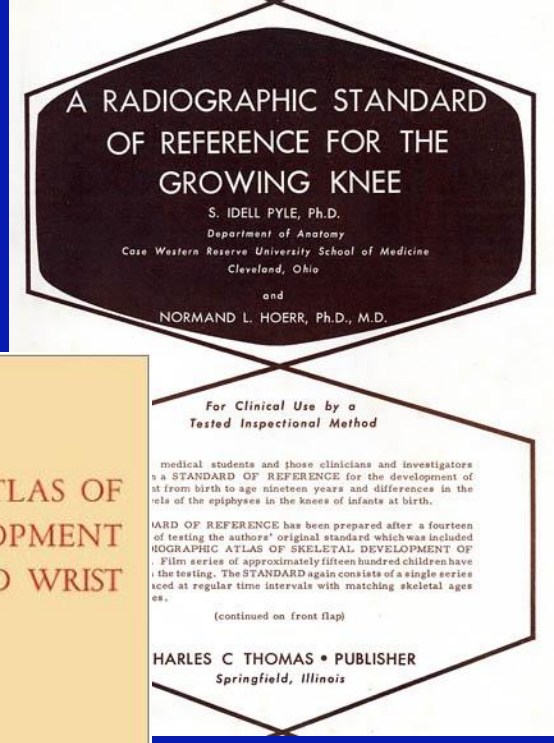
Management and Complications of Anterior Cruciate Ligament Injuries in Skeletally Immature Patients

Kocher et al (*Journal of Pediatric Orthopaedics*, 2002)

- Distal Femoral Valgus with Bony Bar
  - Implants (Interference Screws) across Physis
  - Patellar Tendon graft bone block across Physis
  - Large (12 mm) Tunnel with Patellar Tendon graft
  - Over-the-Top Graft Placement
- Genu Valgum without Bony Bar
  - Lateral Extra-Articular Tenodesis
- Leg-Length Discrepancy
  - 2.5cm shortening (PT bone block across physis)
  - 3.0cm overgrowth (6mm hamstrings graft)
- Recurvatum with Apophyseal Bar
  - Hardware across Tibial Tubercle Apophysis

Evaluation

- Age
  - Chronological Age
  - Skeletal Age
    - Greulich & Pyle
      - Hand & Wrist
  - Physiological Age
    - Tanner & Whitehouse
      - Stage 1: Prepubertal
      - Stage 2: Prepubertal
      - Stage 3: Pubertal: Young Adolescent
      - Stage 4: Pubertal: Older Adolescent
      - Stage 5: Skeletally Mature


A RADIOGRAPHIC STANDARD OF REFERENCE FOR THE GROWING KNEE

S. IDELL PYLE, Ph.D.
Department of Anatomy
Case Western Reserve University School of Medicine
Cleveland, Ohio

and

NORMAND L. HOERR, Ph.D., M.D.

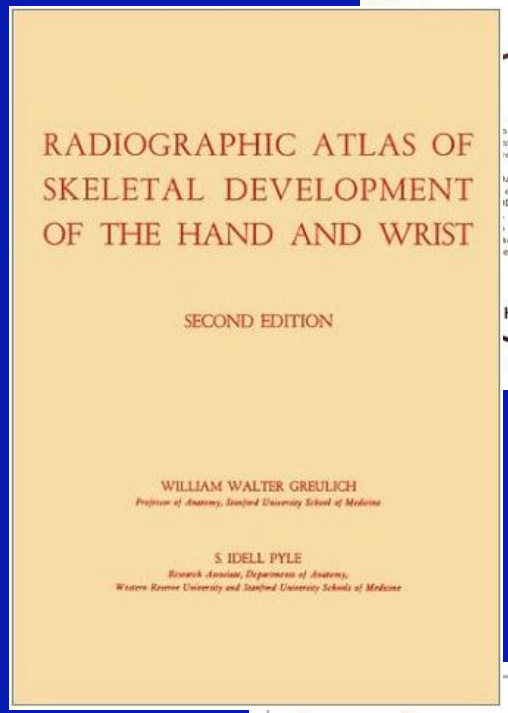
For Clinical Use by a Tested Inspectional Method

medical students and those clinicians and investigators
s a STANDARD OF REFERENCE for the development of
st from birth to age nineteen years and differences in the
vels of the epiphyses in the knees of infants at birth.

ARD OF REFERENCE has been prepared after a fourteen
of testing the authors' original standard which was included
IOGRAPHIC ATLAS OF SKELETAL DEVELOPMENT OF
. Film series of approximately fifteen hundred children have
the testing. The STANDARD again consists of a single series
aced at regular time intervals with matching skeletal ages
es.

(continued on front flap)

HARLES C THOMAS • PUBLISHER
Springfield, Illinois

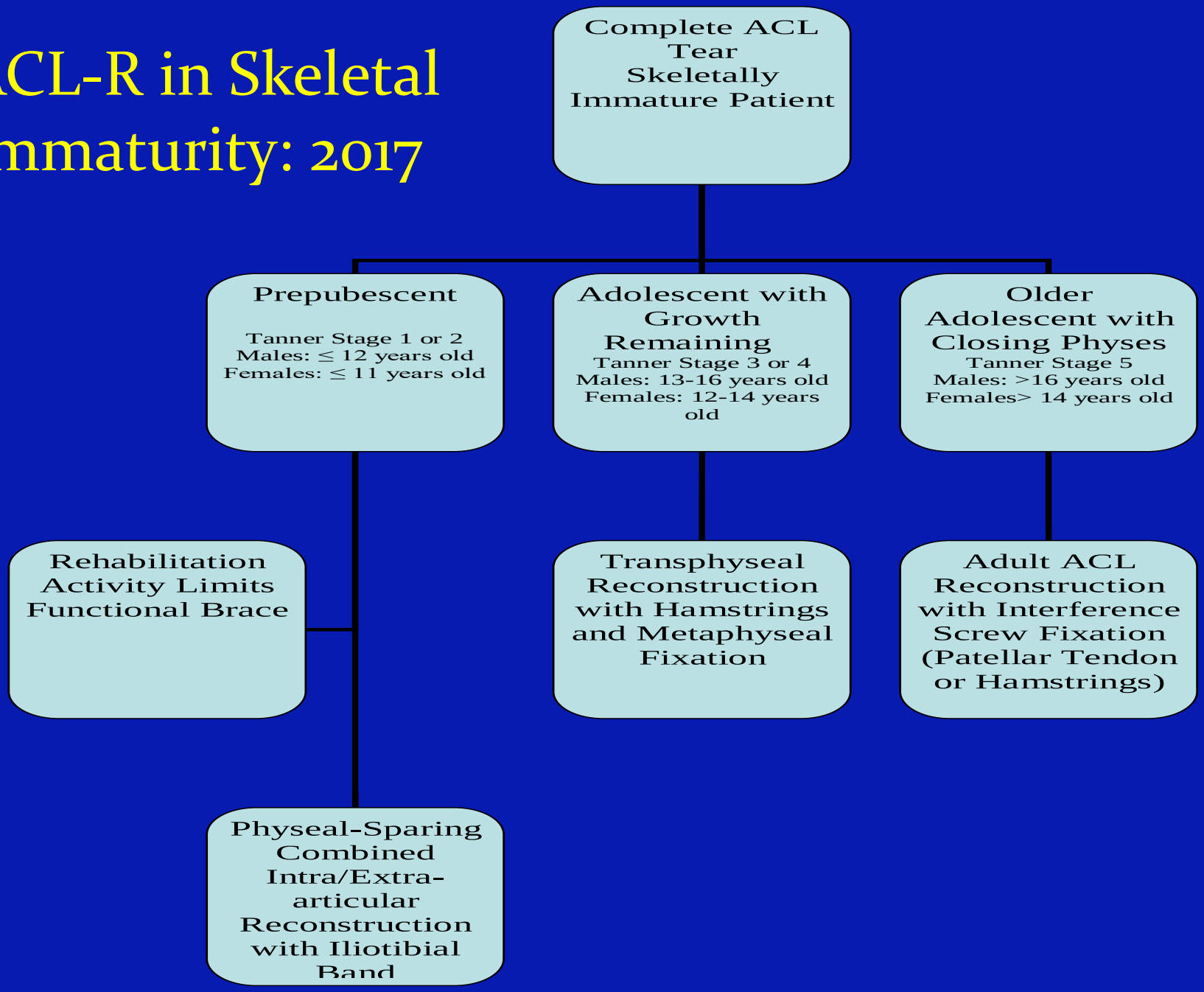

RADIOGRAPHIC ATLAS OF SKELETAL DEVELOPMENT OF THE HAND AND WRIST

SECOND EDITION

WILLIAM WALTER GREULICH
Professor of Anatomy, Stanford University School of Medicine

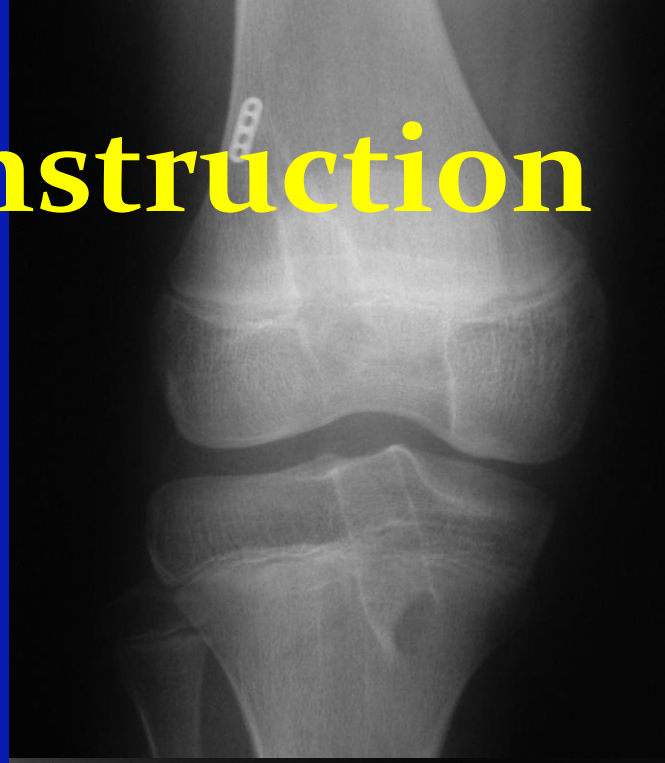
S. IDELL PYLE
Research Associate, Departments of Anatomy, Western Reserve University and Stanford University Schools of Medicine

ACL-R in Skeletal Immaturity: 2017



Transphyseal Reconstruction

- Adolescents with Growth Remaining (T3)
  - Quadrupled Hamstrings
  - Tibial Tunnel
    - More vertical
  - Femoral Tunnel
  - Minimal Notchplasty/ Over-the-Top Dissection
  - Tight Tunnel Fit
    - 8-9 mm
  - Femoral Fixation
    - Continuous Loop Endobutton
  - Tibial Fixation
    - Bioabsorbable Interference Screw/ Post

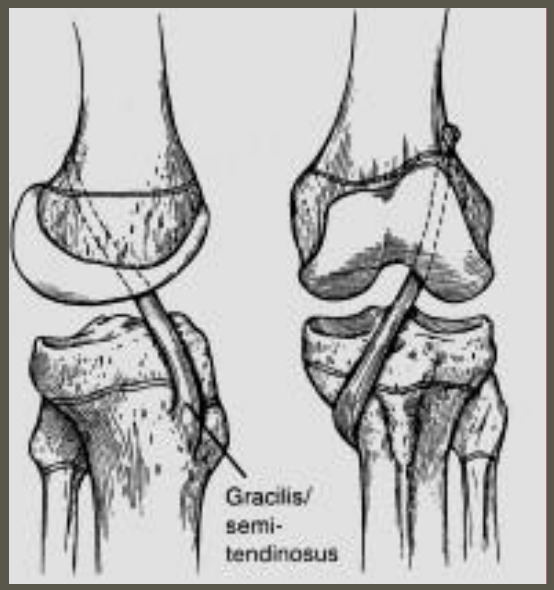


ACL Reconstruction

Extra-Articular

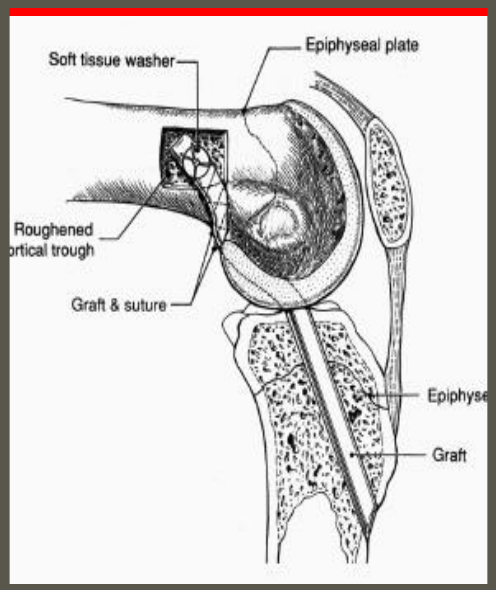
-Dahlstedt 1988
-McCarroll 1988
-Lazzarone 1990
-Graf 1992
-Nakhostine 1995

Physeal Sparing



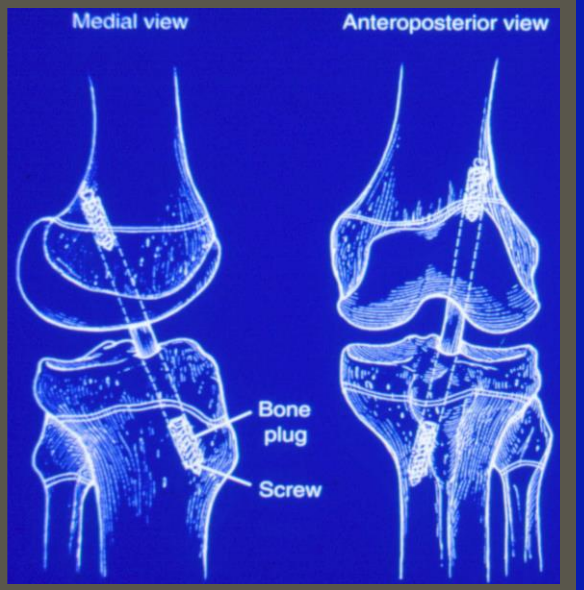
-DeLee 1983
-Brief 1991
-Janarv 1996
-Micheli 1999
-Anderson 2004
-Guzzanti 2004

Partial Transphyseal



-Lipscomb 1986
-Andrews 1994
-Lo 1997
-Bisson 1998

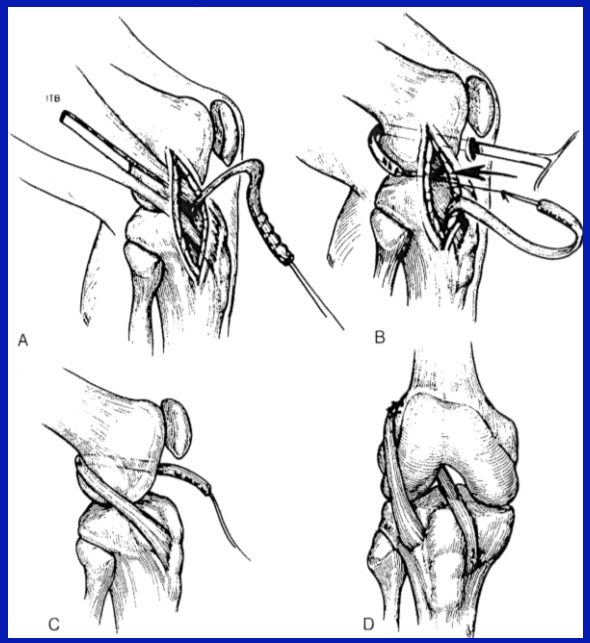
Complete Transphyseal

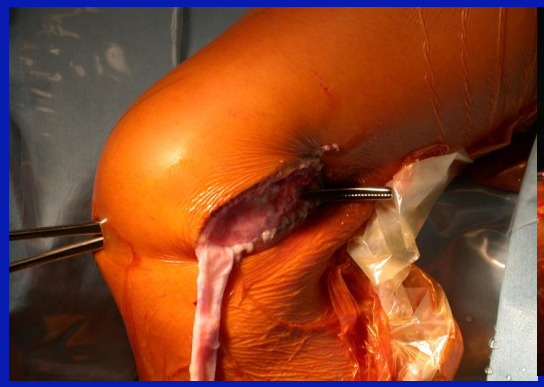


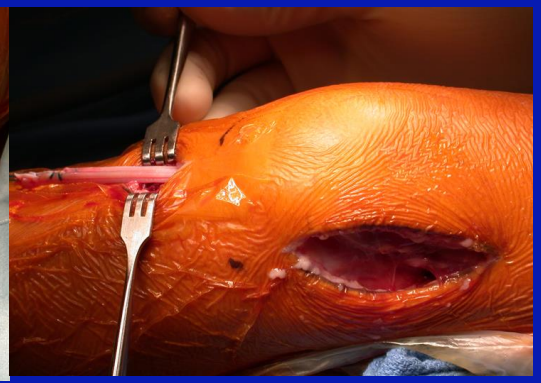
-Lipscomb 1986
-McCarroll 1994
-Matavan 1997
-Aronowitz 2000

Physeal-Sparing Reconstruction

- Growth Remaining
- Techniques – Avoids Physis
  - IT Band
  - Extra-Articular Tenodesis
  - Over-the-Top
    - Minimal dissection
  - Over-the Front
    - Intermeniscal Ligament
  - Fixation







Systematic Review of Studies on ACLR on Skeletally Immature[1]

29 cases – Limb length discrepancy

- 62% Limb overgrowth (1.0cm)
  - Physeal sparing 50%/ Transphyseal 50%
- 38% Limb shortening (1.2cm)
  - Transphyseal

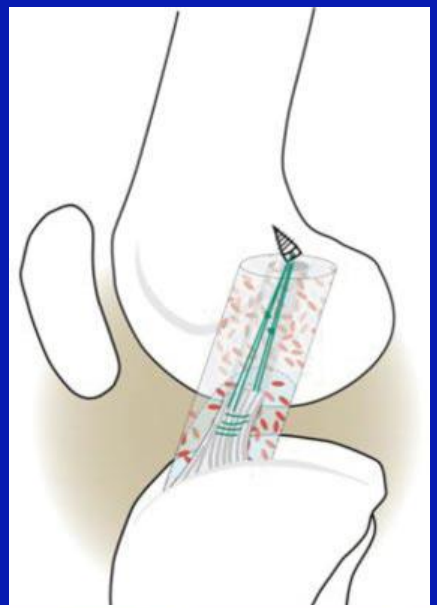
16 cases – Angular deformity/ Genu valgum

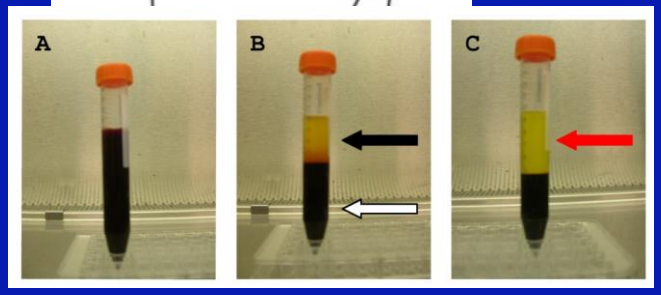
- 75% - Transphyseal (6 deg)
- 25% - Physeal sparing (4 deg)

1. Collins, Arthroscopy, 2016.

Bridge-Enhanced Repair of the ACL (BEAR)

- Suture repair enhanced with a collagen-platelet composite results in functional ACL healing in immature and adolescent, but not adult, animals*
- Human clinical trials underway





1. Murray, AJSM 2016

Summary

- Pediatric Athlete
  - Child athlete is not a little adult athlete
  - Growth plate cartilage is a source of injury unique to children
  - Surgeries are different in children
  - Pediatric sport injuries are a expanding public health problem

Thank You