

# Fractures IN the Knee Pediatric and Adolescent Sports Trauma



Jeffrey M. Vaughn, D.O.  
Phoenix Children's Hospital  
Center for Pediatric Orthopaedics  
Division of Sports Medicine

1

## Disclosures

- I have no disclosures.

2

## Case #1

3

## Case #1



- 13 y/o female softball player
- 2 wks s/p twisting injury L knee while swinging bat
- Pain, swelling, limited ROM, stable ligaments
- Normal radiographs

4

## MRI



- 1.8cm x 0.6cm full thickness chondral defect articular surface lateral femoral condyle

5

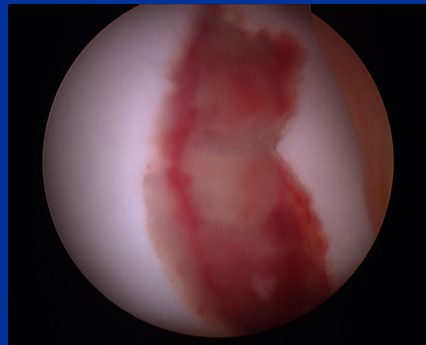
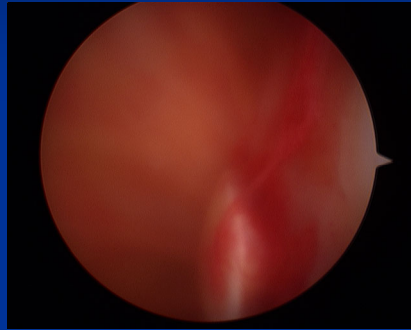
## Osteochondral Fractures



- Mechanisms
  - Direct blow
  - Rotational force
- 25-50% result from patellar dislocation
  - Medial patellar facet or lateral femoral condyle

6

## Arthroscopy



7

## Treatment Options

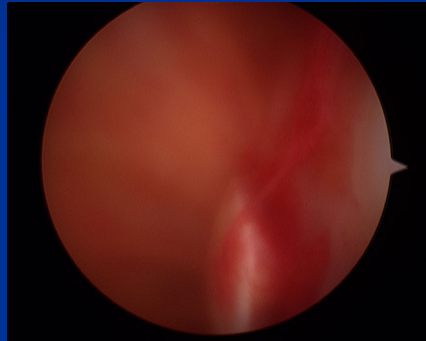
- Reattachment
- Microfracture
- Osteochondral Autograft Transplantation (OATS)
- Autologous Chondrocyte Implantation (ACI)
- Osteochondral Allograft

8

## Osteochondral Fractures Reattachment

### ■ Indications

- >1cm
- Weight bearing surface
- Adequate cortical bone attached to chondral surface

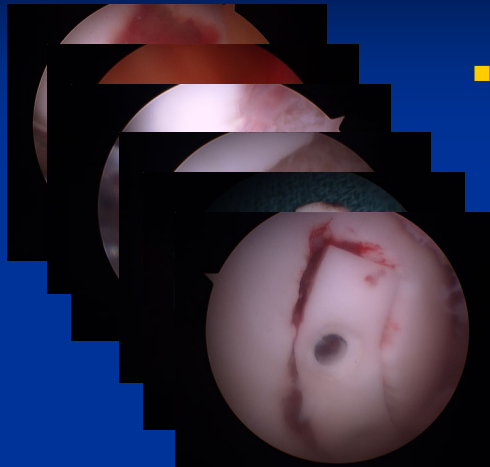


9

## Osteochondral Fractures

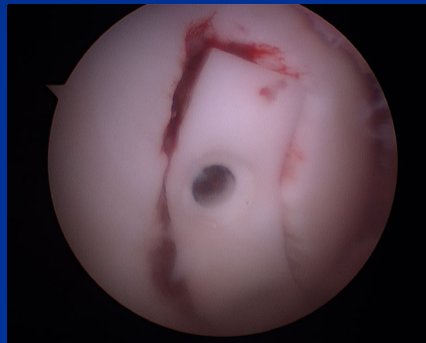
### ■ Technique

- Retrieve fragment
- Debride defect to stable borders
- Remove calcified cartilage layer
- Size cartilage fragment
- Secure in place



10

# Osteochondral Fractures



## ■ Post-operative protocol

- Knee brace
- Progressively advance ROM
- TDWB x 6 wks
- Progressive weight bearing at 6 weeks
- Return to sports 3-4 months

11

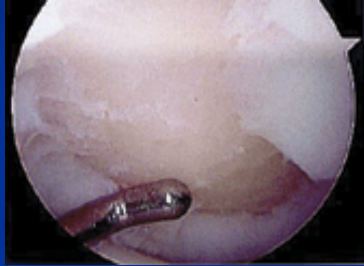
# Unreparable Chondral Defects

## ■ Treatment Options

- Microfracture
- OATS (Osteochondral Autograft Transplant)
- Autologous Chondrocyte Implantation (ACI)
- Osteochondral Allograft

12

# Microfracture

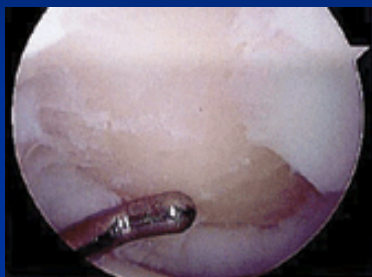


## ■ Indications

- Acute traumatic full thickness loss of articular cartilage
- Size Lesion: No limit

13

# Microfracture

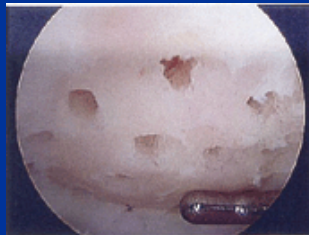


## ■ Technique

- Remove unstable cartilage
- Maintain integrity of subchondral plate
- Create stable perpendicular cartilage borders

14

# Microfracture



## ■ Technique (cont.)

- Perforate subchondral bone with microfracture awl or drill/small wire
- Start peripherally
- Holes spaced 3-4mm apart, 2-4mm deep (marrow elements)
- Decrease pressure, observe bleeding

15

# OATS

## (Osteochondral Autograft Transplant Surgery)



## ■ Indications

- 1-4cm<sup>2</sup> focal defect of weight bearing surface

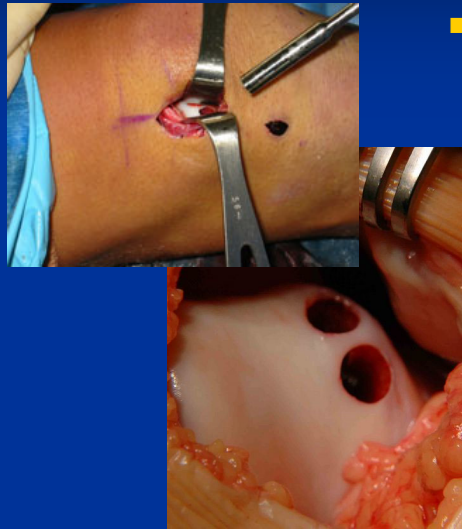
## ■ Contraindications

- Lack of appropriate donor area
- Osteochondral defects deeper than 10mm
- Age > 50 years
- Infection, arthritis

16

# OATS

## (Osteochondral Autograft Transplant Surgery)



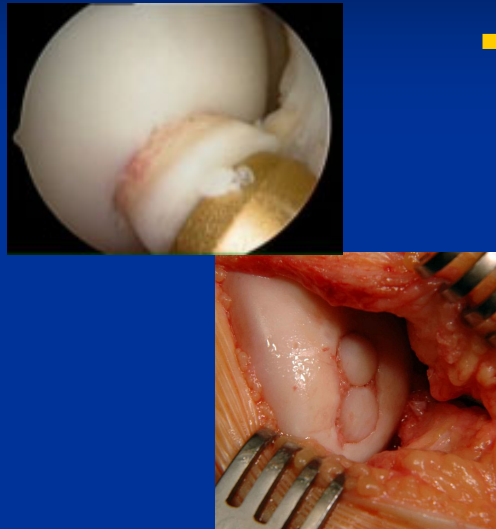
### ■ Technique

- Defect debrided to stable, perpendicular cartilage borders
- Donor cartilage harvested perpendicular to cartilage
- Medial or lateral margin of medial or lateral femoral condyle, superior to sulcus terminalis

17

# OATS

## (Osteochondral Autograft Transplant Surgery)



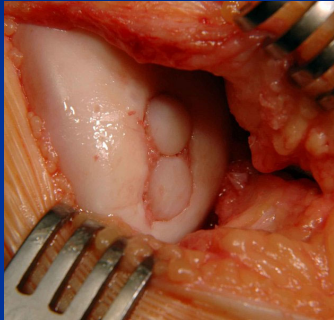
### ■ Technique

- Recipient tunnels drilled
- Congruent surface, 80-90% filling of defect (using combinations of different graft sizes)

18

# OATS

## (Osteochondral Autograft Transplant Surgery)



- Advantages
  - 80-90% filling of defect with hyalin cartilage
- Disadvantages
  - Donor site morbidity
  - Size limited by donor site availability (1-4cm<sup>2</sup>)

19

## OATS vs Microfracture for treatment of OCD lesions, knee

- Prospective, Randomized Study
- 14.3 yrs
- 25 OATS, 22 Microfracture
- Follow-up 4.2 yrs
- Satisfaction
  - Good or Excellent: 1 yr, 86% Microfracture, 83% OATS
- Failures, 4 yrs, less than excellent or good outcomes
  - 41% microfracture
  - 0% OATS
- Return to Sports
  - Microfracture, 7/22 @ 1yr, 3/22 @ 4yrs
  - OATS, 21/25 (84%) @ 1yr, 17/21 (81%) @ 4yrs

JPO, Oct 2009

20

## ACI (Autologous Chondrocyte Implantation)



### ■ Indications

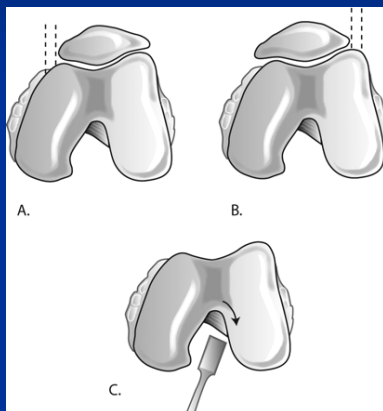
- Symptomatic patients
- Arthroscopically proven cartilage defects
- Grade III-IV chondral defects 2-10cm<sup>2</sup>

### ■ Contraindications

- Untreated axial malalignment
- Ligamentous laxity
- Meniscal insufficiency

21

## ACI (Autologous Chondrocyte Implantation)



### ■ 1<sup>st</sup> procedure

- Biopsy 3 tic-tac sized samples of articular cartilage
- Cells sent to culturing facility – min. 6 weeks

22

## Autologous Chondrocyte Implantation



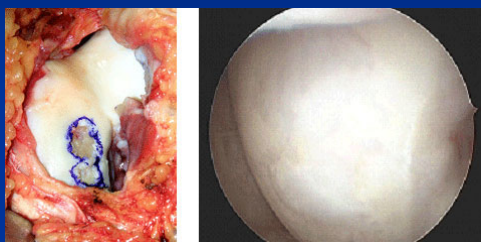
### ■ 2<sup>nd</sup> procedure

#### ■ Prep lesion

- Remove debris
- Create perpendicular margin
- Harvest tibial periosteum or use synthetic graft
- Suture periosteum to defect, seal
- Inject cartilage cells into defect

23

## Autologous Chondrocyte Implantation

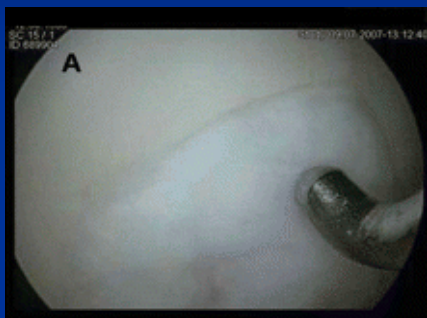


### ■ Post-operative protocol

- CPM
- Restricted weight bearing 6-8 weeks
- Progressive return to low impact sports 4-6 months

24

## Autologous Chondrocyte Implantation



- Advantages
  - Large defects (2-10cm<sup>2</sup>)
  - Hyalin like cartilage
- Disadvantages
  - Overgrowth-most common complication

25

## ACI vs Microfracture

- Systemic Review
- 5 studies
  - 210 patients Microfracture
  - 189 ACI
- Treatment Failure
  - 18.5% **ACI**
  - 17.1% **Microfracture**
- Patient Outcome Scores (KOOS and Lysholm)
  - No significant difference

Kraeutler, AJSM 2018

26

## Autologous Chondrocyte Implantation versus Microfracture

- Saris et al., AJSM, Feb 2008, ACI vs Microfracture
  - ACI: Increased number chondrocyte like cells, higher proteoglycan content, less fibrous tissue
- Kon et al., AJSM, Feb 2009, ACI vs Microfracture
  - Prospective randomized controlled study
  - 80 patients, 5 yr follow-up
  - Return to sports, similar both groups, decreased in microfracture after 2 years

27

## Case #2

28

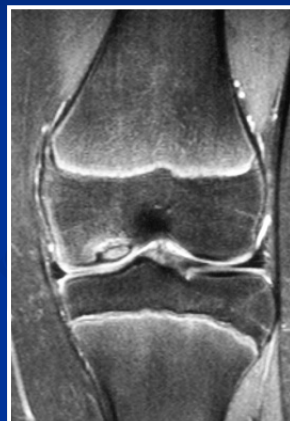
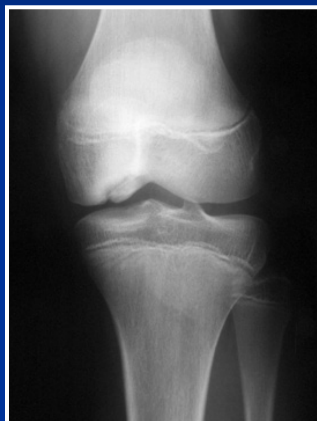
## Case #2



- 11 y/o male c/o unilateral anterior knee pain x 2-3 months
- No known injury
- Worse c activity, stairs, no swelling or c/o instability

29

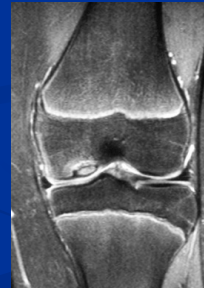
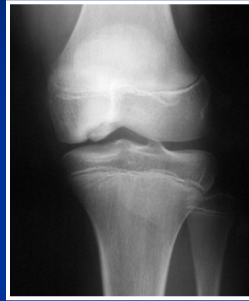
## Imaging



30

# Osteochondritis Dissecans

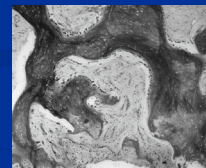
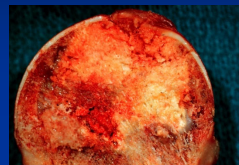
- “Focal, idiopathic alteration of subchondral bone with a risk of instability and disruption of adjacent articular cartilage that may result in premature osteoarthritis.”



31

# Etiology

- Unknown
  - Repetitive microtrauma
  - Acute trauma
  - Genetic
  - Ossification abnormalities
  - Vascular insult
  - Ischemia
- Veterinary Animal Model Research
  - Detailed study of vascularity of knee suggests **vascular etiology** in most cases.



32

## Location

- **Knee (75%)**
- Elbow
- Ankle
- Rarely hip and shoulder



33

## Location

- **Knee**
  - **Medial Femoral Condyle, 64%**
  - Lateral Femoral Condyle, 32%
  - Patella, trochlear groove, tibial plateau, <4%
- Right knee, 50%
- Left knee, 43%
- **Bilateral, 7%** (up to 30% some studies)

Kessler, et al., American Journal of Sports Medicine, 2014

34

## Age

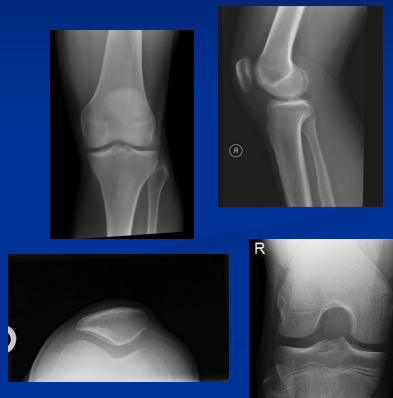
- 2-5 y/o, no lesions
- 6-11 y/o, 53 lesions
- 12-19 y/o, 139 lesions (2.6x greater)
- **Male:** Female, 3.7:1

Kessler, et al., American Journal of Sports Medicine, 2014  
206 OCD Lesions, 192 patients

35

## Imaging

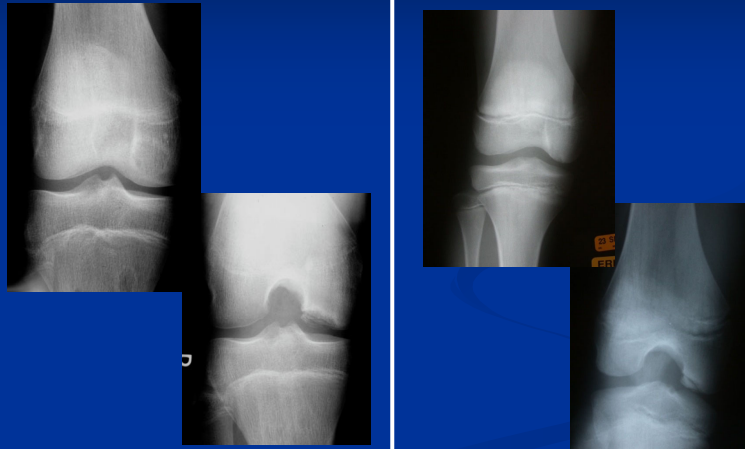
- Standard AP and Lateral radiographs
- **Tunnel and Sunrise Views**
- **Bilateral (30%)**



Jacobi, et al., Association between mechanical axis of the leg and osteochondritis dissecans of the knee: Radiographic Study on 103 knees. Am J of Sports Med 2010

36

## OCD Radiographs

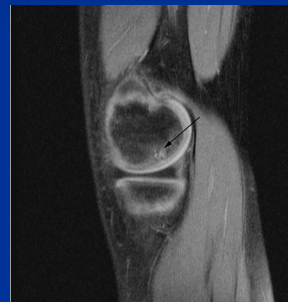


37

## OCD Classification: MRI

Hefti et al

- Stage I: Signal change, No Margins
- Stage II: Clear Margins, No Dissection
- Stage III: Partial Dissection
- Stage IV: Complete Dissection; In-Situ
- Stage V: Free Fragment



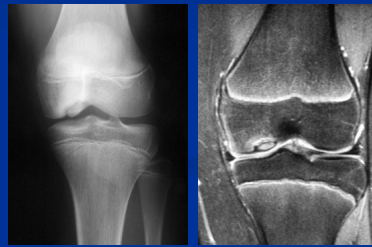
Stage 1

38

## OCD Classification: MRI

Hefti et al

- Stage I: Signal change, No Margins
- Stage II: Clear Margins, No Dissection
- Stage III: Partial Dissection
- Stage IV: Complete Dissection; In-Situ
- Stage V: Free Fragment



Stage 2

39

## OCD Classification: MRI

Hefti et al

- Stage I: Signal change, No Margins
- Stage II: Clear Margins, No Dissection
- Stage III: Partial Dissection
- Stage IV: Complete Dissection; In-Situ
- Stage V: Free Fragment



Stage 3

40

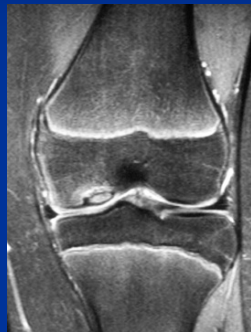
# Nonoperative Treatment OCD



- Initial management
  - Stage I and II lesions
- Restricted weight bearing?
- PT?
- Bracing?
- Low impact activities (walking, cycling, swimming)
- 3-6 months
- Progressive RTS

41

# Treatment OCD



- 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

42

## Operative Treatment jOCD

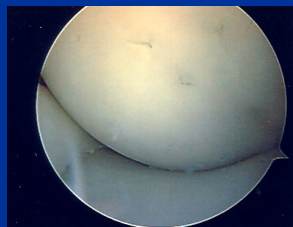
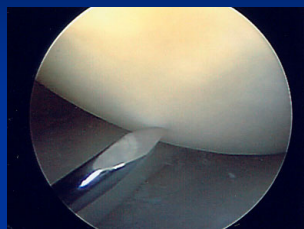


### ■ Indications

- Detached or Unstable Lesions
- Failure of 3-6 months nonoperative tx of stable lesions
- Skeletal Maturity

43

## Operative Treatment Stable OCD Lesions

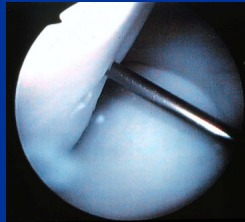


### ■ Drilling

- Rationale
  - Enhance vascularity
- Indications
  - Stable lesion; intact overlying cartilage

44

## Functional and radiographic outcome of juvenile osteochondritis dissecans of the knee treated with transarticular drilling

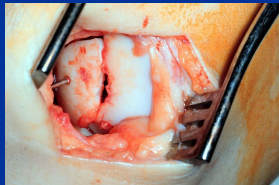
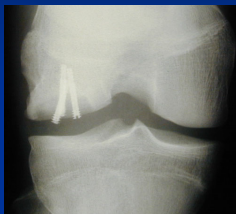


- 30 Knees in 23 Patients
- jOCD (12.3 yrs old)
- 3.9 yr FU
- Isolated Knee Lesion; MFC
- Stable, Intact OCD Lesion
- Failed Nonop Rx: min 6 months
- 30/30 healed (4.4 months)

Kocher, AJSM, 2001

45

## Operative Treatment Unstable OCD Lesions



### ■ Fixation

- Rationale
  - stability
  - fracture healing
- Indications
  - unstable, detached
- Technique
  - screws, wires, tacks

46

## Functional and radiographic outcome of juvenile osteochondritis dissecans of the knee treated with fixation



- 26 Knees in 24 Patients
- jOCD (14.7 yrs old)
- 4.3 yr FU
- Hefti Stage
  - Stage II (fissured): 9
  - Stage III (partially attached): 11
  - Stage IV (detached): 6
  - Fixation
    - Herbert Screw (11), smartnail (10), cannulated screw (3), bioabsorbable pin (3)
  - Healing Rate: 84.6% (22/26)
    - All six stage IV lesions healed

Kocher, AAOS, 2005

47

## Post-Operative

- Bracing
- Weeks 0-6 TDWB
- Weeks 6-12 Low-impact WBAT
  - Walk
  - Cycle
  - Swim
- Week 12 Progressive return to sports



48

## Case #3

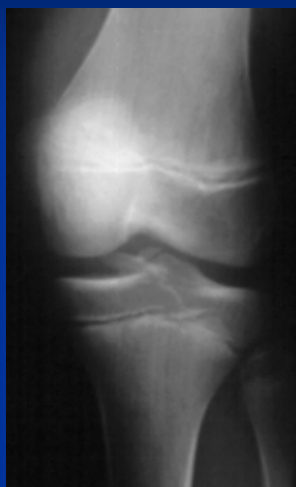
49



- 11 y/o male
- Fall from bicycle
- Knee pain and swelling
- Restricted ROM
- Pain with attempted WB

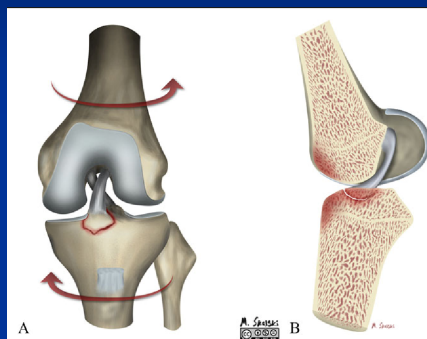
50

## Images



51

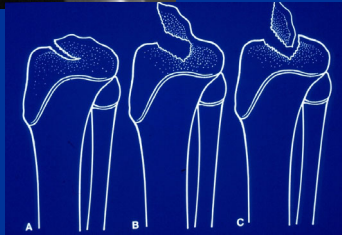
## Tibial Spine Fractures



- “Pediatric ACL injury”
- Anatomy
  - ACL attaches to intercondylar eminence
- Mechanism of Injury
  - Sports
  - Bicycle
- Etiology
  - Relative strength: eminence vs ACL

52

# Tibial Spine Fractures



## ■ Signs & Symptoms

- Hemarthrosis
- Lack extension (bony block)
- Anterior knee laxity

## ■ Imaging

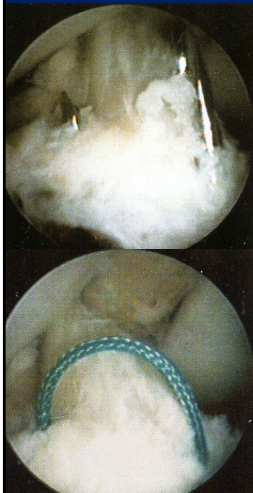
- Lateral knee x-ray

## ■ Classification

- Meyers & McKeever (JBJS 1959)
  - Type I : Minimal displacement
  - Type II : Hinged
  - Type III : Completely displaced

53

# Tibial Spine Fractures



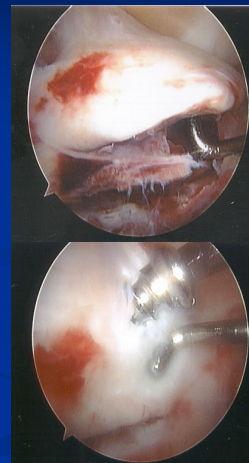
## ■ Treatment Options

### ■ Nonoperative

- Cast Immobilization
- Closed Reduction & Cast

### ■ Operative

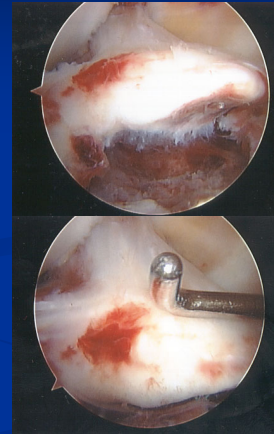
- Open Reduction & Internal Fixation
- Arthroscopic Reduction & Internal Fixation
  - Suture, Screws, Wires



54

# Tibial Spine Fractures

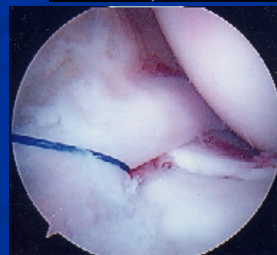
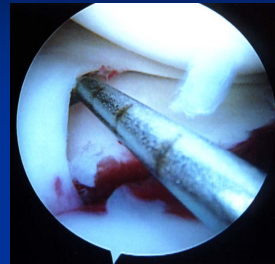
- Displaced Tibial Spine Fracture
  - Benefits of Operative Treatment
    - Anatomic Reduction
      - Lack of Extension
      - Instability
    - Early Mobilization
    - Associated Injuries
      - Chondral Injury
      - Meniscal Injury
    - Entrapped Meniscus



55

## Tibial Eminence Fractures in Children— Prevalence of Meniscal Entrapment

- Retrospective Case Series
  - 80 skeletally immature pts
    - 1993-2001 (n=136)
    - nonreducible tibial spine fx (n=80)
    - 23 Type II, 57 Type III
    - operative treatment
- Findings
  - Meniscal entrapment
    - Type II fx: 26% (6/23)
    - Type III fx: 65% (37/57)



Kocher, AJSM 2003

56

# Tibial Spine Fractures

## ■ Treatment

### Recommendations

- Type I Fractures:
  - long-leg cast: extension
- Type II & III Fractures:
  - Aspiration & Reduction
  - Nonreducible: ARIF
- Fixation Options
  - Cannulated 3.5 mm Epiphyseal Screws
  - Suture



57

## Case #4

58



- 15 y/o soccer player
- Pain, swelling restricted motion knee s/p “landing wrong” while running in soccer.

59

## Fractures of the Tibial Tuberosity



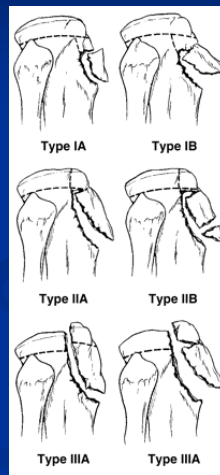
- 90% sports related
- 12-17 y/o
- Jump/land - violent quad contracture

60

# Tibial Tubercle Fractures

## Classification

- Type I: Fracture fragment of tibial tubercle apophysis
- Type II: Tuberosity fracture extends up to proximal tibial physis
- Type III: Fracture extends proximally into articular surface



61

# Tibial Tubercle Fractures

## Treatment



- Nondisplaced
  - Long leg cast x 6 wks.
  - RTS 3 mo.
- Displaced
  - Type I: Look for patella alta
  - Open reduction, internal fixation
  - Older adolescents
    - 6.5-7.3mm cannulated screws
  - Younger children (>3 yrs growth remaining)
    - Smooth pins
  - Type III: Intra-articular eval
    - Anatomic reduction
    - Meniscal eval

62

# Tibial Tubercle Fractures



- Post-op
  - Cast x 4-6 wks
  - Brace 4 additional weeks
  - RTS 4 mo.
- Complications
  - Genu recurvatum
    - Rare – fxs toward end skeletal growth
  - Compartment Syndrome
    - Rare
    - Anterior tibial recurrent artery
      - Retract into anterior compartment when torn

63

## Thank you



64