Physeal-Sparing ACL Reconstuction with Iliotibial Band in the Prepubescent Child

VuMedi Webinar
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Disclosure (November 2013)

- Consulting
  - Biomet
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  - NIH
- Royalties
  - Biomet
- Stock/ Stock Options
  - Pivot Medical
  - Fixes 4 Kids
- Publisher Royalties
  - Elsevier

A Big-Time Injury Striking Little Players' Knees

By GINA KOLATA

Torn Ligament Poses a Greater Risk for Growing Bones

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.

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

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

Sharp Rise in Serious Sports Injuries in Children

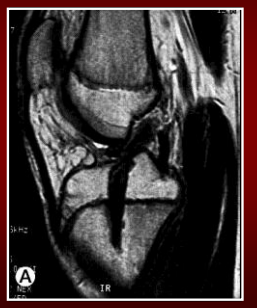
Caleb Seymour, 8, of Holden, Maine, meets New England Patriots quarterback Tom Brady at Gillette Stadium. (ABC News)

abc WORLD NEWS WITH DIANE SAWYER

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

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



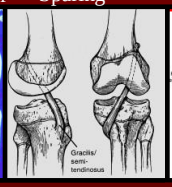
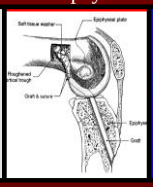
Pediatric ACL Injury

Treatment

- Nonoperative Rx (complete tears):
  - Angel & Hall (*Arthroscopy* 1989)
    - » 5/7 failure (ACL reconstruction)
  - Graf et al (*Arthroscopy* 1992)
    - » 7/8 failure (ACL reconstruction, meniscal tears)
  - Janarv et al (*J Pediatr Orthop* 1996)
    - » 16/23 failure (ACL reconstruction)
  - Mizuta et al (*JBJS-B* 1985)
    - » 1/18 return to preinjury sport level, 6/18 meniscal tears
  - McCarroll et al (*AJSM* 1988)
    - » 3/16 return to preinjury sport, 4/16 meniscal tears
  - Millett et al (*Arthroscopy* 2002)
    - » ⇑ medial meniscus tears with delay in treatment
  - Moksnes H et al (KSSTA 2008)
    - » 20 children, 50% copers, 10% meniscal tear
  - Lawrence et al (*AJSM* 2011)
    - » 70 children: time (OR 4.1), instability (OR 11.4)

Pediatric Knee Injuries

ACL Reconstruction

Extra-Articular	Physeal Sparing	Partial Transphyseal	Complete Transphyseal
			
-Dahlstedt 1988 -McCarroll 1988 -Lazzarone 1990 -Graf 1992 -Nakhostine 1995	-DeLee 1983 -Brief 1991 -Janarv 1996 -Micheli 1999 -Anderson 2004 -Guzzanti 2004	-Lipscomb 1986 -Andrews 1994 -Lo 1997 -Bisson 1998	-Lipscomb 1986 -McCarroll 1994 -Matavan 1997 -Aronowitz 2000

Pediatric ACL Injury

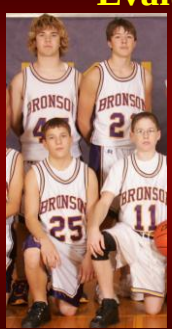
Literature

- Problems
  - Small Series
  - Retrospective
  - Growth Remaining
    - Chronological Age
      - Not Skeletal Age
      - Not Physiological Age
    - Tanner 4

Pediatric ACL Injury

Evaluation

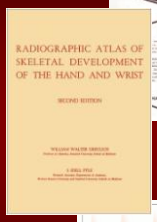
- Age



Pediatric ACL Injury

Evaluation

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



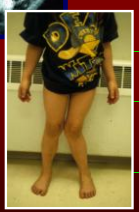
Pediatric Knee Injuries

Growth Disturbance

- Growth Disturbance
  - Animal Models
    - Guzzanti (JBJS 1994)
      - Rabbit, 2mm tunnels, 3/21 Disturbance
    - Stadelmeier (AJSM 1995)
      - Canine, 5/32″ tunnels, No Disturbance
    - Edwards (JBJS 2001)
      - Canine, 80N, Femoral Valgus
  - Clinical Series
    - 2 Cases
      - Lipscomb (JBJS 1986)
      - Koman (JBJS 1999)

Management and Complications of Anterior Cruciate Ligament Injuries in Skeletally Immature Patients: A survey of The Herodicus Society and The ACL Study Group

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

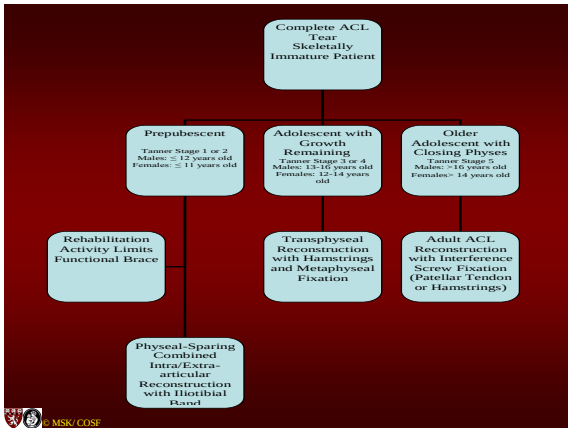


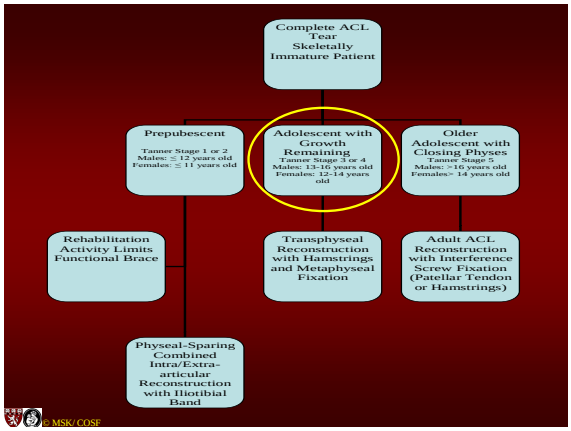
- 8 Cases: Distal Femoral Valgus with Bony Bar
  - 3: Implants (Interference Screws) across Physis
  - 3: Patellar Tendon graft bone block across Physis
  - 1: Large (12 mm) Tunnel with Patellar Tendon graft
  - 1: Over-the-Top Graft Placement
- 2 Cases: Genu Valgum without Bony Bar
  - Lateral Extra-Articular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

Pediatric Knee Injuries

Growth Distu

- 10 yr old male
  - Transphyseal ACLr
  - Auto Hamstrings
- 16 yr old male
  - Graft Failure
  - Valgus Deformity
- Revision ACLr
  - Allograft
  - Osteotomy

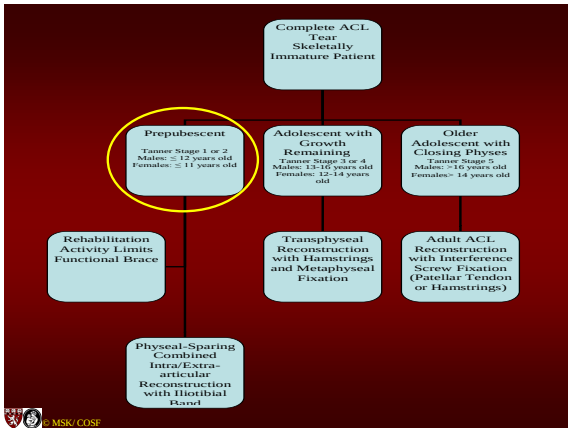




Pediatric ACL Injury

Transphyseal Reconstruction

- Transphyseal ACL reconstruction with autogenous hamstrings and metaphyseal fixation *(Kocher et al: JBJS 2007)*.
  - 61 knees/ 59 pts (14.7 yrs old (11.6-16.9))
  - 3.6 yr follow-up (2.0-10.2)
  - 3.3% revision rate
  - IKDC: 89.5 ± 10.2/ Lysholm: 91.2 ± 10.7
  - 8.2 cm growth (1.2 - 25.4 cm)
  - No growth disturbance
- This technique appears provides for excellent functional outcome with a low revision rate and minimal risk of growth disturbance.



Pediatric ACL Injury

Physeal-Sparing Reconstruction

- Prepubescents
- Options
  - Nonoperative Treatment
  - Transphyseal (Paletta, Pinczewski)
  - Epiphyseal (Anderson, Ganley)
  - IT Band Physeal Sparing
- Technique
  - MacIntosh 2 variation
  - Extra/Intra-Articular
    - Over-the-Top
    - Over-the Front
  - Trade-Off
    - Nonanatomic vs Physeal-Sparing

Pediatric Knee Injuries

Physeal-Sparing Reconstruction

Pediatric Knee Injuries

Physeal-Sparing Reconstruction

- Physeal-Sparing Combined Intra/ Extra-Articular ACLr with IT Band
- Kocher et al (*J Bone Joint Surg*, 2005)
  - 44 pts (10.3 yrs old (3.6-14.0))
  - 5.3 yr follow-up (2.0-15.1)
  - 4.5% revision rate (4.7 & 8.3 yrs)
  - IKDC: 96.7 ± 6.0
  - Lysholm: 95.7 ± 6.7
  - 21.5 cm growth (9.5 – 118.0)
  - No growth disturbance
  - Video Journal of Orthopaedics (3/06)

Pediatric Knee Injuries

Physeal-Sparing Reconstruction

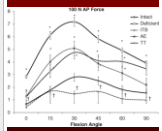
Biomechanical Evaluation of Pediatric Anterior Cruciate Ligament Reconstruction Techniques

Abbey Kennedy,* MD, Dezba G. Coughlin,* PhD, Melodie F. Metzger,* PhD, Ronald Tang,† BS, Andrew D. Pearle,† MD, Jeffrey C. Lotz,* PhD, and Brian T. Feeley,*§ MD
Investigation performed at the Department of Orthopaedic Surgery, University of California San Francisco, San Francisco, California

Figure 3.

Anteroposterior (AP) laxity as a function of knee flexion angle. Sectioning of the ACL resulted in a higher AP translation at all flexion angles. The iliotibial band (ITB) reconstruction resulted in AP displacement that was not significantly different from the intact state. The all-epiphyseal (AE) ACL reconstruction was not able to restore AP stability to the knee; that is, the AP translation remained significantly greater than the intact state at higher flexion angles. The transtibial over-the-top (TT) reconstruction technique led to significantly higher anterior translation than the ACL-intact state at greater flexion angles (45°, 60°, and 90°).

*$P < .05$ vs intact. †Not significant vs intact.



Pediatric Knee Injuries

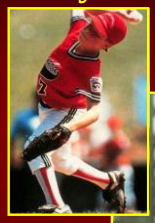
Agenda

- Nonoperative Treatment
- Partial Tears
- Treatment Options
- Growth Disturbance
- Treatment Algorithm
- Conclusions

Pediatric Knee Injuries

Summary

- Pediatric Athlete
  - "Child is not a little adult."
  - "Child athlete is not a little adult athlete."



Pediatric ACL Injury

Conclusions

- Recommendations
  - Know Patient's Growth Remaining
  - Shared Decision Making
    - Risks: Nonoperative Treatment
      - Meniscal/ Chondral Injury
    - Risks: Operative Treatment
      - Growth Disturbance
  - Understand Pediatric Knee Anatomy
    - Distal Femoral Physis & Over-Top
    - Proximal Tibial Apophysis
    - Avoid Hardware/ Bone across Physis
  - Technique
    - Adolescents:
      - Transphyseal Hamstrings
    - Prepubescents:
      - Physeal-Sparing


Thank You

ACL Injuries in the Young Athlete

All Epiphyseal and Post Pubertal Reconstruction

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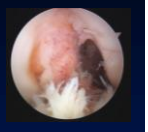

November, 5th, 2013

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Director of Sports Medicine at
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Sports Medicine *and* Performance Center *at*
The Children's Hospital *of* Philadelphia

Associate Professor, Department of Orthopaedic Surgery
The University of Pennsylvania School of Medicine

DISCLOSURES

I, Theodore Ganley, have NO relevant financial relationships to be discussed, directly or indirectly, referred to or illustrated with or without recognition within the presentation as follows:

- Reviewer/editor
  - The American Academy of Pediatrics
  - The American Journal of Sports Medicine
  - Clinical Orthopedics and Related Research
  - The Journal of Bone and Joint Surgery
  - The Journal of Pediatric Orthopedics
  - The University of Pennsylvania Orthopedic Journal
- Advisory Board
  - The American Academy of Pediatrics Orthopedic Section
  - IPOS – International Pediatric Orthopedic Symposium

ACL Injuries in the Young Athlete

Goals / Objectives

1. Injuries Increasing
2. All Epiphyseal ACL
3. Post-Pubertal ACL
4. Present evidence based options

ACL Injury

Pre and Post Pubertal ACL

- Over 10 yrs

The Children's Hospital of Philadelphia 2011 AAP

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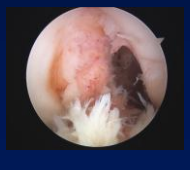
ACL Injury

Pre and Post Pubertal ACL

- Over 10 yrs
  - 914 ACL, 996 meniscal tears, 155 tibial spines
    - Tibial spine fractures (controls)

400% increase in ACL injuries ($p<0.001$)
Multivariate linear regression analysis



The Children's Hospital of Philadelphia 2011 AAP

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ACL Injury

Who is getting injured?

Females > Males, Same Sports, Same Schools

Goldberg, Flynn, Ganley 2006

- Females - significantly greater risk/rate of these injuries relative to males

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ACL Injury

What can be done?

- Goal: Prevent injuries
  - or reduce the injury rate/severity

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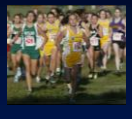
ACL Injury

Pediatric ACL Prevention Programs can increase strength & performance



Theodore J. Ganley, MD
Jeffrey Albaugh, PT, MS, ATC

European Pediatric Orthopedic Society
Pediatric Orthopedic Society of North America
International Pediatric Orthopedic Symposium

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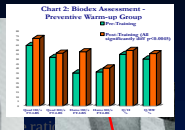
ACL Injury

Improvement? – Yes

Warm up prevention group

- Improvements P<0.004
  - 6 Strength measures
    - Quadriceps peak torque at 180 and
    - Hamstring peak torque at 180 and
    - Quad/Hamstring and Quad/Body w
  - 3 Performance measures
    - vertical jump unilateral, vertical ju



- Drop jump screen - Landing
  - Higher percentage improved alignment from a prio
    valgum biased" landing

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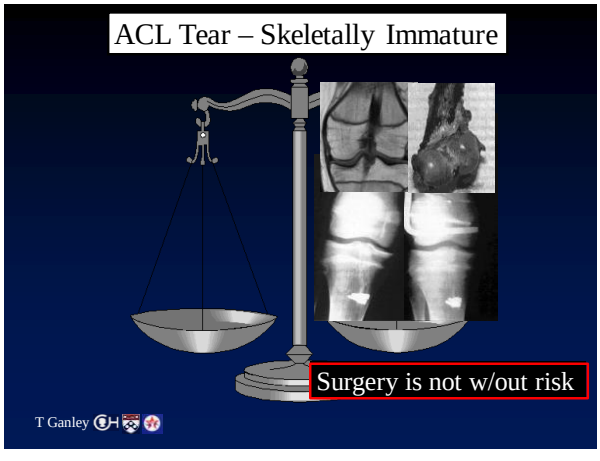
ACL Tear – Skeletally Immature
Surgery is not w/out risk
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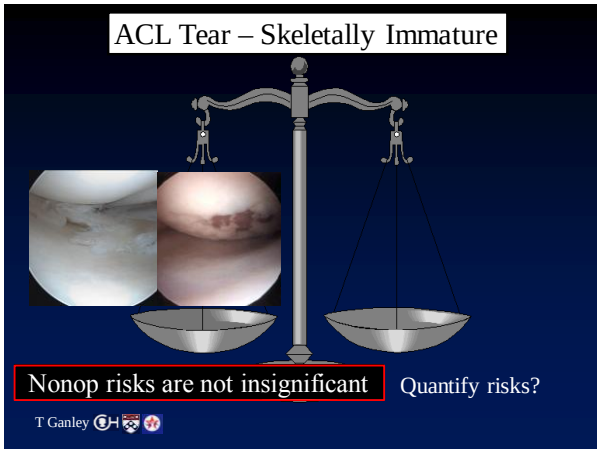
ACL Tear – Skeletally Immature
Nonop risks are not insignificant
Quantify risks?
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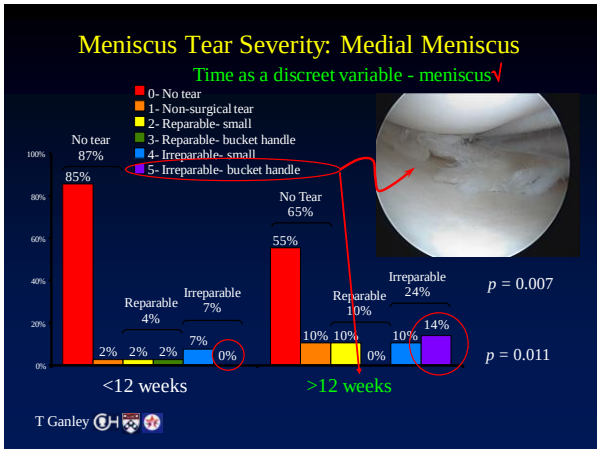
Meniscus Tear Severity: Medial Meniscus
Time as a discreet variable - meniscus√
0- No tear
1- Non-surgical tear
2- Reparable- small
3- Reparable- bucket handle
4- Irreparable- small
5- Irreparable- bucket handle
No tear 87%
85%
Reparable 4%
Irreparable 7%
2% 2% 2% 7% 0%
No Tear 65%
55%
Reparable 10%
Irreparable 24%
10% 10% 0% 10% 14%
p = 0.007
p = 0.011
<12 weeks
>12 weeks
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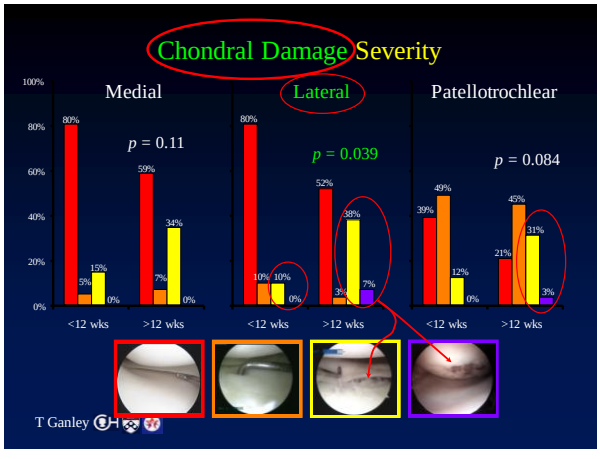
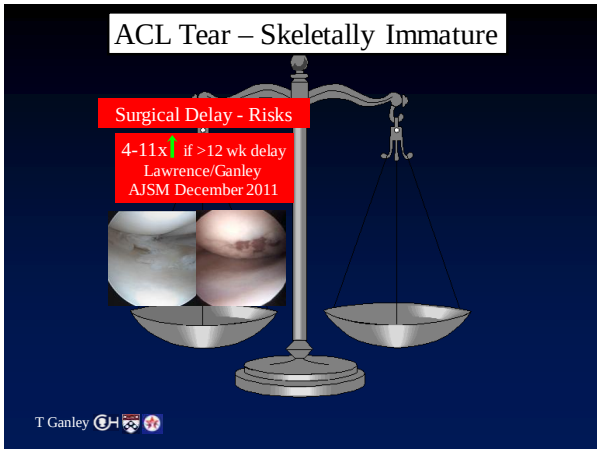

Chondral Damage Severity
Medial
Lateral
Patellotrochlear
p = 0.11
p = 0.039
p = 0.084
80% 5% 15% 0%
59% 7% 34% 0%
80% 10% 10% 0%
52% 3% 38% 7%
39% 49% 12% 0%
21% 45% 31% 3%
<12 wks
>12 wks
T Ganley


ACL Tear – Skeletally Immature
Surgical Delay - Risks
4-11x if >12 wk delay
Lawrence/Ganley
AJSM December 2011
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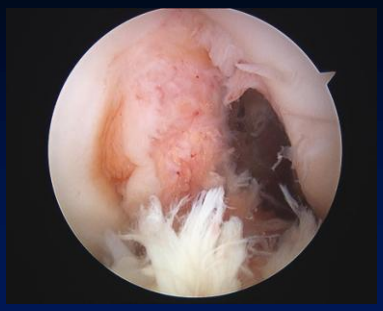
Operative Treatment



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Pediatric ACL Injury

Intra-articular Extraphyseal

- Well documented
  Performed for over 30 years

Micheli, Clin Orthop 1999
Kocher, Micheli, JBJS 2003

Min

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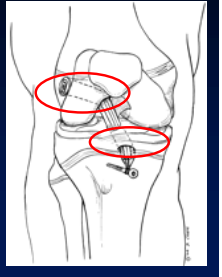
Pediatric ACL Injury

2 All Epiphyseal ACL

Established
Performed for over 25 years
Published in JBJS

JBJS 2003

Allen F. Anderson, MD



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Pediatric ACL Injury

Transepiphyseal Replacement of the Anterior Cruciate Ligament

- KT, Scanograms, Return to sport
- Mean IKDC 96.5 (86-100)
- No: Growth arrest,
  LLD,
  or significant side to side diff.

Allen F. Anderson, MD

JBJS 2003

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All-epiphyseal ACL Reconstruction Improves Tibiofemoral Contact: An In Vitro Study

All-epiphyseal ACL reconstruction
shifts contact anteriorly on the tibia compared with injured knee
potentially reduce risk of cartilage damage & meniscal injuries
without violating the growth plate in pediatric patients

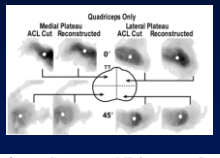


TABLE 1. *P*-values for Anterior-posterio
Reconstructed Cases

	Medial		
	Anterior-posterior		
	Q&A	Q	Q&H
0 degree	0.02	0.004	0.006
15 degrees	0.01	0.02	0.002
30 degrees	0.003	0.001	0.02

Matthew J. Stonestreet, MD, Kerwyn C. Jones, MD,† Marcus S. Kirkpatrick, MD,* Kushal S. Shah, BS,*‡ Caroline E. Frampton,*‡ Melanie A. Morscher, PT,† and John J. Elias, PhD**

T Ganley

J Pediatr Orthop 2012: 15-20

Pediatric ACL Injury

All Epiphyseal ACL

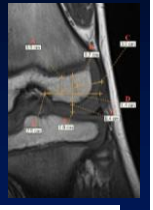
Anatomic Landmarks Utilized for Physeal-Sparing, Anatomic Anterior Cruciate Ligament Reconstruction

An MRI-Based Study

MRI's of 188 children (range 6-17)
Extra-articular and intra-articular landmarks identified.
3D recons - to confirm femoral tunnel placement

Note landmarks

"Center of the ACL femoral footprint & the popliteus insertion safe, reproducible, anatomic ACL reconstruction"



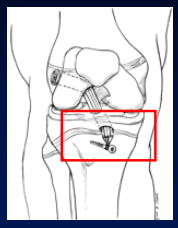
John W. Xerogeanes, MD, Kyle E. Hammond, MD, and Dane C. Todd, BS

T Ganley

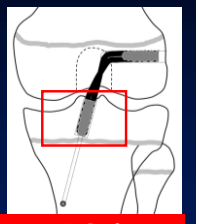
JBJS Feb 2010:268-276

Pediatric ACL Injury

All Epiphyseal ACL



Anderson



T. Ganley
T. Lawrence
CORR 468: 1971-77, 2010

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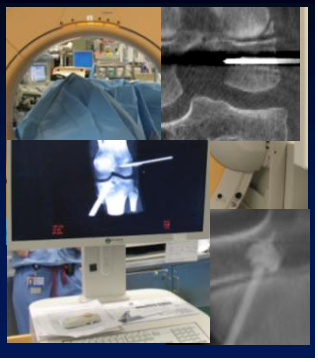
Pediatric ACL Injury

All Epiphyseal ACL

- Freddie Fu
  - 3D CT cover footprint post op
  - Stringent criteria when developing technique



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All Epiphyseal ACL

Clinics in Sports Medicine 2011

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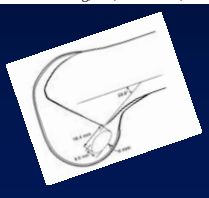
ACL Deficiency

All Epiphyseal ACL

- Principle
  - Tunnels - at the femoral and tibial footprint
    - Reference

James F. Heming, DO, Jason Rand, PA-C, and Mark E. Steiner,* MD

AJSM 2007



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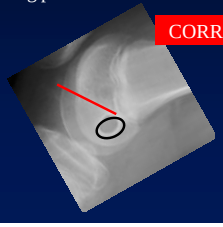
ACL Deficiency

All Epiphyseal
Femoral and Tibial

- Principle
  - Tunnels
    - Radiograph – tg patient

CORR 468: 1971-77, 2010



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All-epiphyseal, with Quadrupled Semitendinosus Autograft

Eric J. Sarkissian, B.S., Theodore J. Ganley, M.D.
Division of Pediatric Orthopaedic Surgery, The Children's Hospital of Philadelphia

ACL tears in skeletally immat
treatment remains controversi
• Non-operative mis
damage?
• Operative reconstr
consequent angul

We developed and previously
using a socket in the tibia to pl
equipment refinement allows
less invasive and less disrupti

Graft Preparation

• Quadrupled semitendinosu
• Two ACL TightRope® RT
placed on opposite ends of
• Alternatively, TightRope®
Implant & Button may be u
tibial side

Socket Preparation

• Pilot tracks created by guide
confirmation of positioning w
arm 3-D CT scanner (Medtron
Minneapolis, MN)
• C-arm imaging acceptable

into femoral and

CL reconstruction:

documented by
y
. Set. Prevent.

and using buttons to
letally immature
escent patients.

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ACL Deficiency

All Epiphyseal

Femoral and Tibial

- Growth plate avoiding acl is your …
  - Tunnel footprint
  - Fixation Method
  - Graft
  - Rehabilitation

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ACL Deficiency

All Epiphyseal

Femoral and Tibial

- Your Methods "with a few caveats"
  - Tunnel footprint: (not at/compressing physis)
  - Fixation Method (not compressing physis)
  - Graft (typically not allograft)
  - Rehabilitation (modified - or you can have mine)

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3 Transphyseal drilling

Is this a viable option? (in those approaching maturity) (Bone Age 13/14, Tanner 3 or 4)

- Ham/Quadriceps – Lo, ICL 47,1998
- Patellar Tendon Allograft - Fuchs, Arthroscopy 2002
- Fascia Lata Allograft – Andrews, AJSM 1994
- Achilles Tendon Allograft
  - – Aronowitz, Ganley, Gregg: AJSM 2000
- Hamstring Autograft –

Aronowitz/Ganley et al. AJSM 2000
Kocher/Micheli et al. JBJS 2007

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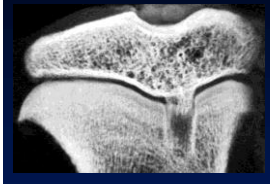
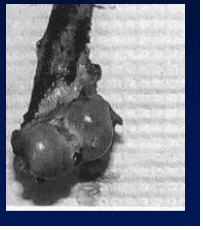
Transphyseal Reconstruction

√ Need to follow rules?





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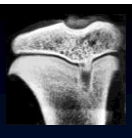

Pediatric ACL Injury

Sequelae

- Mathematical models – Wester, JPO 2002
  - 13 y/o m / 21° Valgus / 2.5 cm Shortening
- Basic Science Models
  - Bone Bridge tunnels left empty - Arnoczky
  - Beagles / 75 N / LLD + Valgus - Edward, JBJS Am 2004
- Clinical Reports – Koman, Sanders JBJS 1999
  - Transphyseal screw: Valgus - Fem Osteotomy
- Survey – Kocher, Procs ACL Study Group, 2002
  - 15 growth disturbances / 8 w/ BTB or device across physis
- Unpublished Reports…

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3 Post Pubertal ACL

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Clinics in Sports Medicine 2011

Hybrid ACL Reconstruction

All Epiphyseal Femoral

Transphyseal Tibial

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Clinics in Sports Medicine 2011

Hybrid ACL Reconstruction

Growth plate avoiding

Growth plate respecting

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Clinics in Sports Medicine 2011

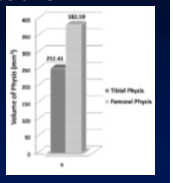
Pediatric ACL Injury

Data for Transphyseal Component

Volumetric Injury of the Physis During Single-Bundle Anterior Cruciate Ligament Reconstruction in Children: A 3-Dimensional Study Using Magnetic Resonance Imaging

Mean % physeal volume removed/total physeal volume

6mm, 7mm, 8mm 9mm diamater hole
1/6%, 2.2%, 2.9%, 3.8%, for the tibia
2.4%, 3.2%, 4.2% 5.4%, for the femur



Kevin G. Shea, M.D., Jen Belzer, B.S., Peter J. Apel, M.D., Kurt Nilsson, M.D., M.S., Nathan L. Grimm, B.S., and Ronald P. Pfeiffer, Ed.D., L.A.T., A.T.C.

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Arthroscopy 2009 : 1415-22

Conclusion

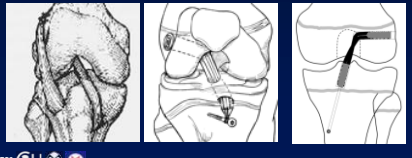
Persistently Symptomatic ACL Tear

↓

Growth Plates "Wide Open"

↓

can be avoided



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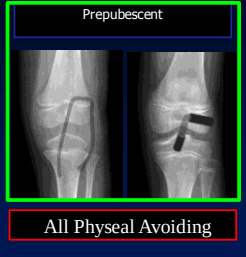

All Physeal Avoiding

T Ganley Clinics in Sports Medicine 2011

2 All Epiphyseal

All Physeal Avoiding

T Ganley Clinics in Sports Medicine 2011

3 Transphyseal

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Partial Physeal Avoiding

T Ganley Clinics in Sports Medicine 2011

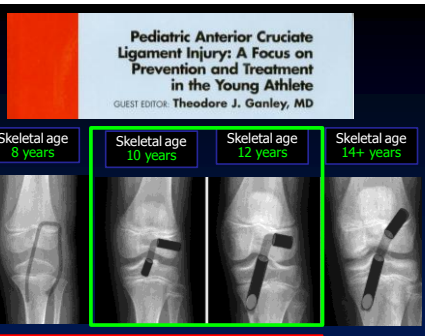
Hybrid ACL Reconstruction

All Epiphyseal Femoral

Transphyseal Tibial

Partial Physeal Avoiding

T Ganley Clinics in Sports Medicine 2011



Physeal Avoiding

Transphyseal

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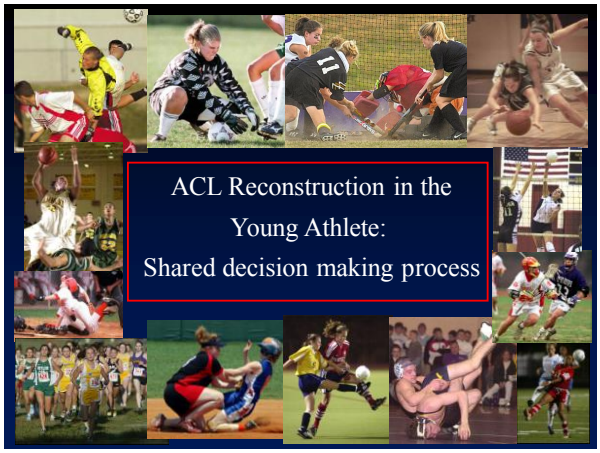

ACL Reconstruction in the Young Athlete: Shared decision making process

We can control our…

Decision making, Tunnels, Graft, Fixation, Rehab

However…

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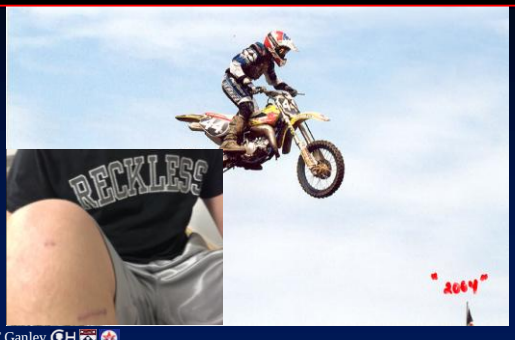
…we can't control patient behavior



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ACL Injuries in the Young Athlete

Goals / Objectives

1. Injuries Increasing
2. All Epiphyseal ACL
3. Post-Pubertal ACL
4. Present evidence based options

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Thank You!

T Ganley

Sports Medicine *and* Performance Center *at*
The Children's Hospital *of* Philadelphia

Patellofemoral Instability in Skeletally Immature Athletes

Nov 5, 2013: Vumedi Webinar

William Hennrikus MD
Professor of Orthopaedics
Associate Dean of Education
Penn State College of Medicine
Email: WLH5k@hotmail.com

Disclosures--none

Neither I, William Hennrikus MD, nor any family members have any relevant financial relationships to be discussed, directly or indirectly, referred to or illustrated without recognition within the presentation



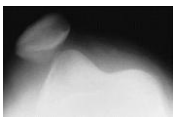
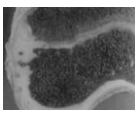





Outline

Adolescent Athlete—skeletally immature-- with a patella dislocation

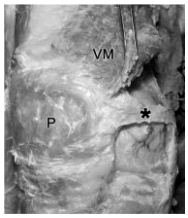
- **What's hot in the literature**
- **How do I treat---**
  - ***1st time dislocation**
  - ***Repeat dislocations**
  - ***Growth plate open**
- **Summary**

Philippot R Knee 2009
Bicos J AJSM 2007

Medial Patellofemoral Ligament--MPFL

- **New 'holy grail' of PFInstability surgery**
- **#1 medial stabilizer of the patella**
- **MPFL repair or reconstruction is a key option in the treatment of PF Instability**



Primary restraint to PF Instability at 0-30 flexion

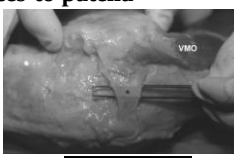
Overall, provides > 50% of medial restraint forces to patella

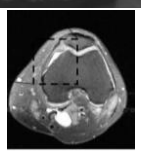
Origin

- Adductor tubercle—medial femoral epicondyle--near physis

Insertion

- Upper 2/3 of medial patella
- About 55 mm long

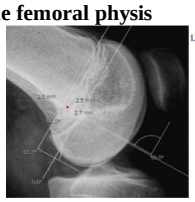


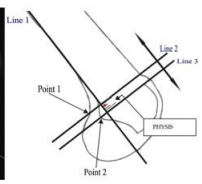


The relationship of the femoral physis and the MPFL

Shea K et al. Arthroscopy 2010

- **The origin of the MPFL is 3 mm proximal to the femoral physis**





- **Avoid physeal injury when reconstructing the MPFL in immature athletes**

1st time Acute patella dislocation in children and adolescents: a randomized clinical trial.

Palmu et al. JBJS 90A:2008

- 62 patients under age 16
- No osteochondral fractures
- 2 year clinical follow up; 16 year phone follow up
- Initial operative repair of the medial structures combined with lateral release did not improve the long term outcome
- **Routine repair of the 'torn medial stabilizing soft tissues' is not advocated for 1st time dislocation**

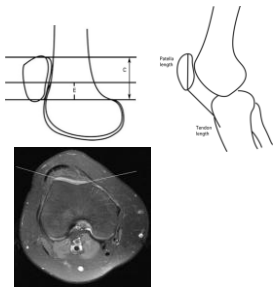
The patho-anatomy of patellofemoral dislocation

Monk A JBJSB 2011

Dynamic MRI study of 60 patients

Factors associated with PF Instability

- **< 30% patella engagement in trochlea**
- **Patella Alta**
- **TT-TG > 20 mm**
- **Trochlea dysplasia**



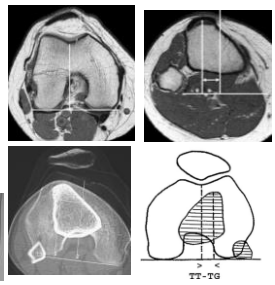
TT TG distance

> 20 mm abnormal

Tecklenburg K JBJSB 2010

CT or MRI

- **Distance between the center of the trochlear groove and the center of the attachment of the pat tendon to the tib tubercle**
- **Demonstrates excessive lateralization of the tib tub with high valgus vector on the patella**
- ***Imaging method to measure Q angle***



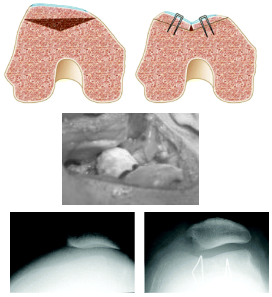
Patellar Fracture after MPFL Reconstruction Parikh, S, Wall E JBJSA 2011

- 5 patella fractures p MPFL reconstuction
- **Recommend** avoid transverse drill hole in patella, single tunnel, adequate bone bridge, consider other techniques

The Role of Trochleoplasty

Bollier et al JAAOS 2011
Utting et al JBJS B 2008
F von Knoch JBJS B 2006

- Trochleoplasty should be reserved for severe dysplasia in which other options fail
- A 'developing procedure'
- Not recommended if growth plates open



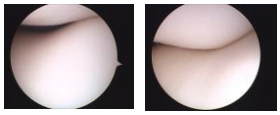
The Role of Lateral Retinacular Release

Clifton et al JBJSB 2010
Fithian D et al Arthroscopy 2004

- Isolated LR is rarely performed among experienced knee surgeons
- Isolated LR in ineffective when treating PFInstabililty

Effects of LR

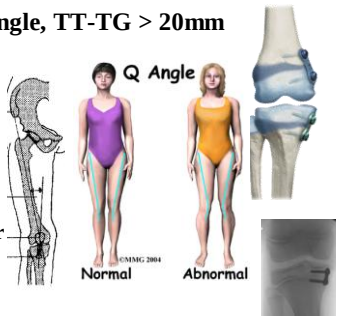
- PF contact pressure minimally changed
- Center of PF contact medialized between 60 and 120 deg flexion
- Decreased pressure on lateral facet in flexion
- Reduced lateral tilt
- **Denervation of lat retinaculum**



Guided Growth

High Q angle, TT-TG > 20mm

- **Stevens et al JPO 2008**
- **Saran et al JAAOS 2010**
- **Ballal et al JBJSB 2010**
- **Goldman et al Curr Op Peds 2010**



How do I treat—

Athlete with first PF dislocation—no additional pathology

- **RICE**
- **Knee Immobilizer and towel**
- **Rehab: quad, hams, core—gluteal and abdominal muscles, hip ext and abd**
  Powers et al CORR 2003
- **Patella sleeve**
- **Soft foot orthotic**

Non-operative treatment

Nikku Acta Ortho Scand 1997
Andrade Knee/Arthroscopy 2002
Fithian Am J Sp Med 2004
Stefancin CORR 2007

- **Rehab**
- **VMO strengthening**
- **Core strengthening**
- **Hip strengthening**
- **Taping/ bracing**
- **Shoe insert**
- **Activity modification**

Operative Treatment

1st time dislocator
and concomitant pathology

- Osteochondral fracture
- MPFL tear
- VMO avulsion
- Meniscal tear

1st time dislocator has a 1 in 5 chance of repeat DL

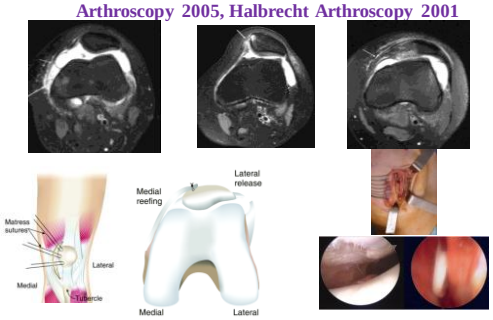
Repeat dislocator

1 in 2 chance of repeat dislocation

- Proximal soft tissue surgery: ***MPFL reconstruction***
- Distal re-alignment: --soft tissue procedure
- Guided growth
- Combo

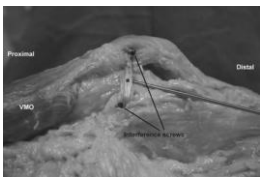
Mini open medial repair or reefing combined with lateral release

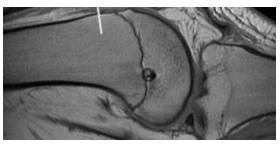
Fithian OTSM 1999,Nam AJSM 2005, Steensen Arthroscopy 2005, Halbrecht Arthroscopy 2001



Athlete with Recurrent PF Instability
MPFL Graft and Fixation Choices

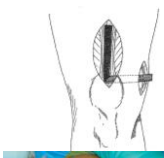
- **Hamstrings: Burks 2007**
- **Patella Tendon: Camanho 2007**
- **Quadriceps: Noyes 2006**
- **Add Mag: Teitge 2006**
- **Allograft: hyperlaxity**





Quadriceps tendon

Noyes, Albright Arthroscopy 2006




Rehab

- Hinged brace 6 weeks
- Motion 0-30,30-60, full
- Wht bear 50% and advanced over 6 weeks to full
- Jog by 3 months
- Sports by 6 months

Complications

- Stiffness
- Painful hardware
- Patella fracture
- PF arthrosis

Outcomes

Smith Knee Arthros 2007

- Review of 8 papers, 174 pts
- 2 yr follow up
- 90% Excellent results

Contra-indication

Pre-exisisting PF arthritis

Bony malalignment

- Re-alignment osteotomy
- Guided growth hemi-epiphyseodesis
- Distal/proximal procedures

Traditional distal realignment

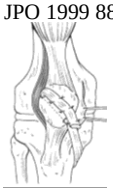
Skeletally immature athlete

Galeazzi Semitendinosus Tenodesis

Galeazzi 1922 Italy

Open Physis--no TT ost

- Baker JBJS 1972 80%
- Letts JPO 1999 88%



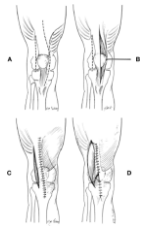
- **Grannatt, Micheli, Kocher et al. JPO 2012** Safe but 82% repeat subluxation—35 % second surgeries
- Temporizing surgery—open physis
- ***May need bony realignment surgery after skeletal maturity***

Traditional proximal/distal realignment

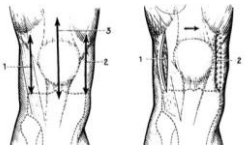
Skeletally immature athlete

Can lead to abnormal contact pressure, stiffness

Insall CORR 1972



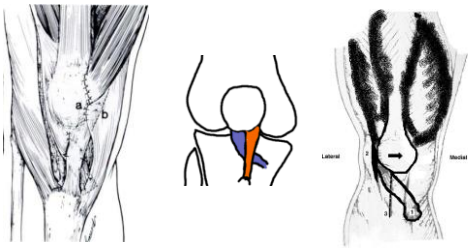
Scuderi JBJSA 1988



Traditional proximal/distal realignment

Modified Roux Goldthwait Procedure

Fondren JBJS 1985, Marsh JPO 2006



Miserable Malalignment

Delgado et al JPO 1996 9 patients

Stevens et al JPO 2004 14 patients

- All with Pat-femoral pathology
- Failed conservative therapy

- Fem ext rot osteotomy
- Tibial int rot osteotomy
- No additional soft tissue procedures were done to affect patella femoral tracking

Summary

Pat fem instability in skeletally immature athlete

- **Challenging clinical problem**
- **Open physis must be protected**
- **Some children will have recurrent instability despite well done surgery**
- **Ligamentous laxity and patella alta**

What is hot

- **Evolution from non-anatomic extensor mechanism operations to a more anatomic procedure based on reconstitution of the MPFL**

Review Articles

- Hennrikus W, Pylawka T. Patellofemoral instability in skeletally immature athletes. J Bone Joint Surg 2013;95A:176-183.
- Pace JL, Hennrikus WL, Kocher MS. Surgical treatment of patellar instability in skeletally immature athletes. RV West and AC Covin, Eds. The Patellofemoral Joint in the Athlete. Springer 2013.

Thank You

Traumatic Patellar Dislocation: in the patient approaching skeletal maturity

- Jennifer M. Weiss, MD
- Southern California Permanente Medical Group
- Pediatric Orthopedic Surgery and Sports Medicine

12 year old male with "knee dislocation"

- Differential
  - Patellar dislocation
  - ACL tear

Patellar Dislocation and Instability in Kids

- Peak incidence: 15 years
- Traumatic dislocation
  - Usually noncontact
    - LE internal rotation with knee valgus on planted foot
  - Direct blow laterally on patella

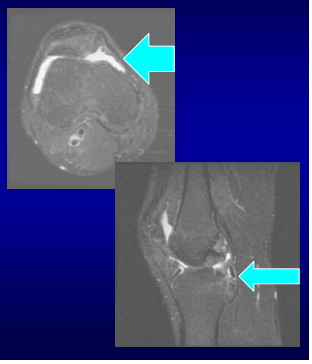
Patellar Dislocation

- History:
  - knee "gave out" or "popped out"
  - Most spontaneously reduce
- Physical Exam:
  - Effusion
  - Apprehension test

Apprehension test

Considerations: IMAGING

- X-Ray: may miss loose body
- MRI
  - loose body?
  - Trochlear dysplasia?



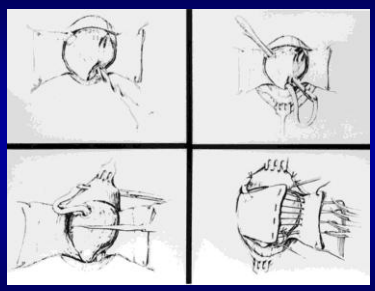
Nonoperative considerations

- Bracing or casting: initial immobilization
  - » Maenpaa, Acta Orthop Scand, 1997,
- Rehabilitation
- Counseling: this may happen again
  - 38% recurrence rate
  - 69% recurrence rate in the setting of trochlear dysplasia
    - » McIntosh 2013

Patellar Dislocation and Instability in Kids: Surgical Options

- Operative:
  - Tibial tubercle transfer contraindicated if growth plate is open
  - Galeazzi procedure: semitendinosis transfer to patella
  - Roux Goldthwait procedure
  - MPFL reconstruction
  - Lateral release??? Probably not alone

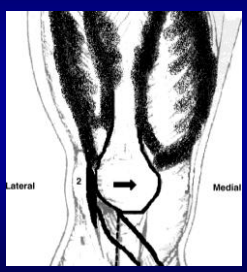
Semitendinosis transfer to patella: Galeazzi Technique



Letts, Davidson, et al, JPO, November 1999

Roux-Goldthwait procedure

- Lateral ½ of patellar tendon transferred medially to sartorius insertion
- Lateral release



MPFL: anatomy

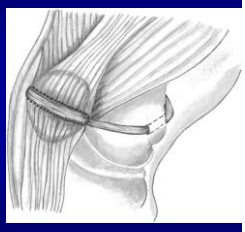
- Extracapsular fascial band
- Femoral attachment??
  - distal to the adductor tubercle and posterosuperior to the medial epicondyle
  - Cadaver study: femoral attachment proximal to physis over age 10, distal to physis under age 10 (Kevin Shea et al)
- Patellar attachment
  - Superomedial patella
- Passes deep to VMO
- 5.5 cm long
- 3? Cm wide

MPFL: function

- Constraint to lateral subluxation of patella
- Tears or stretches when patella dislocates
- Consideration for primary repair for first time dislocator??

MPFL reconstruction

• Good results even with trochlear dysplasia



- Steiner et al, Am J of Sports Med, 2006
- Donnell et al, Am J of Sports Med, 2006

Surgical technique

- Stability exam

Surgical technique

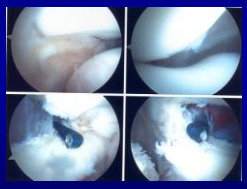
- Harvest & whipstitch Semi-Tendinosus tendon

MPFL Technique

- Harvest semitendinosus
- Usually size 4.5

MPFL technique

- Arthroscopic exam
- Evaluate for loose bodies
- Lateral release if patellar tilt
  - Stop at inferior border of patella



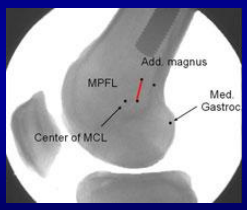
Patellar fixation

- Suture anchor

Patellar fixation

MPFL technique

- Tunnel graft under VMO
- Fix to femur in middle of epiphysis using interference screw

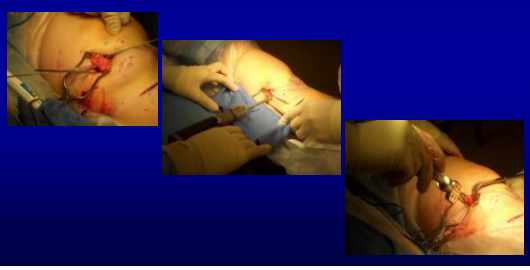


Femoral Fixation

- Passed under Vastus Medialus
- Femoral fixation drilled under Fluoroscopic guidance
- Middle of epiphysis

Femoral fixation

- Interference screw



Post Surgery Protocol

- 6 weeks hinged knee brace
- Encourage range of motion ASAP
- Crutches PRN
- Therapy for ROM and strength
- Back to sports 4-6 months

Patient Selection for MPFL

- Traumatic dislocators
- Atraumatic dislocators who have failed
  - Therapy
  - Bracing
  - More therapy
  - More bracing

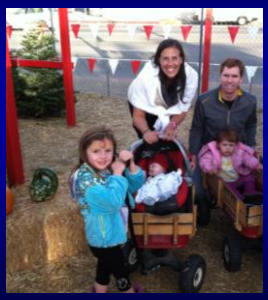
Who Needs MORE??

- Neuromuscular issues
  - Cerebral palsy
- Laxity issues
  - Down's Syndrom
  - Ehler's Danlos
- Habitual Dislocators
- Alignment issues??
  - Miserable malalignment

What is “MORE”??

- Open lateral release
- Distal procedure
  - Tibial tubercle transfer
  - Roux Goldthwait

Thank You



Pediatric Sports Medicine Symposium

Nonoperative Management of Medial Humeral Epicondyle Fractures

Lawrence Wells, MD

Associate Professor of Orthopaedic Surgery

The Children's Hospital of Philadelphia
Perelman School of Medicine
University of Pennsylvania

DISCLOSURE

My disclosure is in the Final Program

I have no conflicts

Medial Humeral Epicondyle Fx

Do Not Fix

Medial Humeral Epicondyle Fractures

- 12% OF ELBOW INJURIES
- PEAK AGE 11 Y

Wilkins KE. Fractures involving the medial epicondylar apophysis. In: Rockwood CA Jr, Wilkins KE, King RE, 1991. p 509-828.

- 5-15 mm displacement
- FOOSH

L Wells

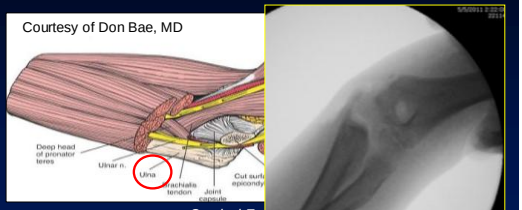
"Only" Incarcerated Medial Humeral Epicondyle Fractures Should Be Fixed…

L Wells

Additional Indications for surgery…

- Ulnar nerve entrapped in joint
- Elbow is "markedly" unstable

Courtesy of Don Bae, MD

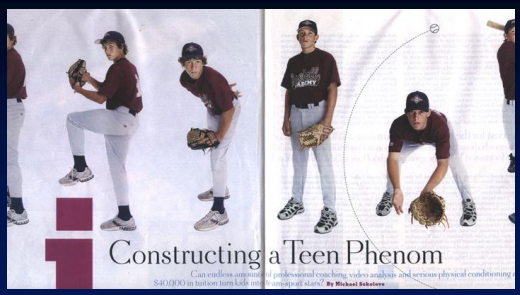


Surgical Ex
Hoppenfe

Our Daily Challenge…

L Wells

Our son has a fracture….You need to fix it…



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Reality
Going to the Pros..
Baseball

Approximately **one in 200**, or approximately 0.45 percent of high school senior boys playing interscholastic baseball will eventually be drafted by an MLB team.

L Wells

Medial Humeral Epicondyle Fx

Farsetti et al, JBJS 2001

- 42 patients
- Ave age 45 years at 30 year f/u
- Poor results with excision

30 year f/u

LONG-TERM RESULTS OF TREATMENT OF FRACTURES OF THE MEDIAL HUMERAL EPICONDYLE IN CHILDREN

BY P. FARSETTI, MD, V. POTENZA, MD, R. CATERINI, MD, AND E. IPPOLITO, MD

Investigation performed at the Department of Orthopaedic Surgery, University of Rome "La Sapienza," Rome, Italy

Conclusions: In our study, nonsurgical treatment of isolated fractures of the medial humeral epicondyle with between 5 and 15 mm of displacement yielded good long-term results similar to those obtained with open reduction and internal fixation. The nonunion of the epicondylar fragment that was present in most patients who had been treated only with a cast did not adversely affect the functional results. Surgical excision of the medial epicondylar fragment should be avoided because the long-term results are poor.

39 yr f/u…full motion despite asymptomatic nonunion..

Fig. 1-A Fracture of the right medial humeral epicondyle with marked displacement in a twelve-year-old boy, treated with cast immobilization only.
Fig. 1-B Thirty-nine years after the injury, the patient had a full range of motion of the elbow, despite nonunion of the medial humeral epicondyle. The carrying angle of the affected elbow measured 15°. The final result was rated as good.

Farsetti JBJS 2001

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Nonoperative RX
35 year F/U

Epicondylar elbow fracture in children

35-year follow-up of 56 unreduced cases

Fifty-six conservatively treated children (7–17 years) with a displaced (1–15 mm) fracture of the medial humeral epicondyle were examined 35 (21–48) years after the injury. In 31 cases a pseudarthrosis had developed of which 3 had mild ulnar nerve symptoms. The function and range of motion of the elbow was good in all cases.

Per O. Josefsson
Lars G. Danielsson

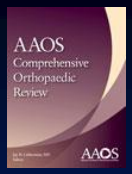
Lund University, Department of Orthopedics at Malmö General Hospital, S-214 01 Malmö, Sweden

Acta Orthop Scand 57:313-315

35 yr f/u asymptomatic nonunion

L Wells

The Literature is divided….



- Surgical treatment
- Indications
  - Absolute—Intra-articular entrapment of the medial epicondyle…..I agree….
  - Relative—Dominant arm in a throwing athlete, weight-bearing extremity in an athlete (eg, gymnast), ulnar nerve dysfunction.

L Wells

Confusing literature..

- Systematic Reviews..
- Kamath
- Pappas
- Klatt

L Wells

Systematic Reviews


J Child Orthop (2009) 3:345–357
DOI 10.1007/s11832-009-0192-7

ORIGINAL CLINICAL ARTICLE

Operative versus non-operative management of pediatric medial epicondyle fractures: a systematic review

Atul F. Kamath · Keith Baldwin · John Horneff · Harish S. Hosalkar

- 14 studies included
- Pseudoarthrosis is common in Non op group
- No difference in pain at at final followup

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Medial Humeral Epicondyle Fractures

We don't know how bad it is…

How Displaced Are "Nondisplaced" Fractures of the Medial Humeral Epicondyle in Children? Results of a Three-Dimensional Computed Tomography Analysis

By Eric W. Edmonds, MD

Investigation performed at Rady Children's Hospital and Health Center, San Diego, California

L Wells

Medial Humeral Epicondyle Fractures

We don't agree…

Intraobserver and Interobserver Agreement in the Measurement of Displaced Humeral Medial Epicondyle Fractures in Children

By Nick Pappas, MD, John T. Lawrence, MD, Derek Donegan, MD, Ted Ganley, MD, and John M. Flynn, MD

Investigation performed at the Children's Hospital of Philadelphia, University of Pennsylvania, Philadelphia, Pennsylvania

L Wells

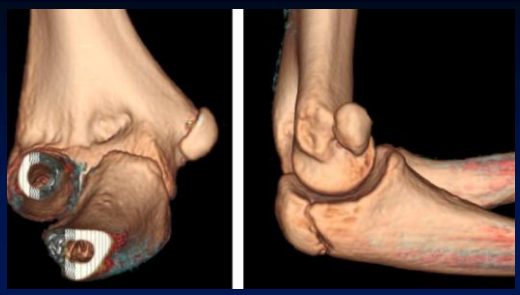
Standard Radiographs are inconclusive... but does it matter....

Pappas vs Klatt discordant xray review outcomes

L Wells

19

Do we need a CT ?... Does it matter?...



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Medial Humeral Epicondyle Fractures

Complications

J Pediatr Orthop • Volume 31, Number 2, March 2011

Iatrogenic Radial Nerve Injury With Cannulated Fixation of Medial Epicondyle Fractures in the Pediatric Humerus: A Report of 2 Cases

David M. Marcu, MD, Joshua Balts, BS,* James J. McCarthy, MD,† Scott H. Kozin, MD,‡§ and Kenneth J. Noonan, MD**

Firstly, the use of a terminally threaded pin seems to be a risk factor. They seem to decrease the "feel" of the second cortex, so that advancement beyond the second cortex is much more likely, and potentially threaded pins are more likely to "wrap" or entangle the nerve. Second, the unique

Complications

Broken screw

Displaced Fx + failed surgery

Appeal for Evidence…

Medial Epicondyle Fractures in Children: Clinical Decision Making in the Face of Uncertainty

Charles T. Mehlman, DO, MPH and Andrew W. Howard, MD, FRCS(C), MSc†*

Carefully designed prospective studies, including randomized studies, are required before evidence-based pediatric orthopaedics can improve on the clinical recommendations derived from observational studies in the historical literature.

L Wells

As we Wrestle with Value….

L Wells

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Value

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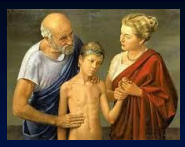
Our first charge is….



Primum non nocere

First Do No Harm

L Wells

Medial Humeral Epicondyle Fractures

MOST… DON'T NEED FIXING!

35 yr f/u

Figure 2. Fractured medial epicondyle with a displacement of 4 mm.
A. The fresh injury.
B. Healed medial epicondyle with a typical groove formation 33 years after injury.

A B

L Wells

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Medial Humeral Epicondyle Fractures

- MOST… DON'T NEED FIXING!
- LAWRENCE et al AJSM 2013

Return to Competitive Sports After Medial Epicondyle Fractures in Adolescent Athletes

Results of Operative and Nonoperative Treatment

All 20 patients were able to return to playing their sport(s) at the next appropriate higher level given their age, irrespective of the treatment received.

Medial Humeral Epicondyle Fractures

- CONCLUSIONS…
- Non operative Treatment
  - Long arm cast 3 weeks
  - Early ROM as pain dissipates
- Return to ADL's and sports..

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Thank You

WellsL@email.chop.edu

Medial Epicondyle Fractures: To Fix

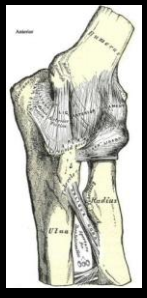
Eric W Edmonds, M.D.

Disclosures

- None pertinent to this talk

Introduction

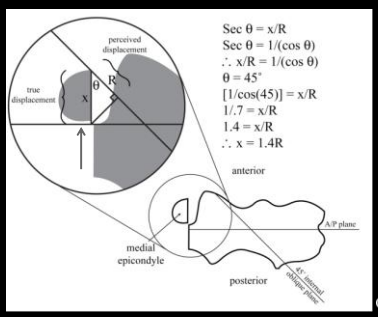
- Anatomy
  - Anterior and posterior bundle of the medial collateral ligament
  - Pronator teres, flexor digitorum superficialis, flexor carpi radialis and ulnaris



Introduction

- Pathomechanics
  - Displacement based on muscle vectors
  - Question utility of AP radiographs

Trigonometry



Real Question

- What is acceptable displacement?


- No acceptable answer to this question.

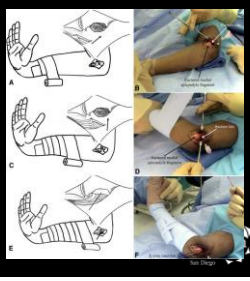
Current recommendations?

- Surgical Indications
  - AP x-ray displacement
    - > 2 mm
    - > 3 mm
    - > 5 mm
    - > 10 mm

  - Intra- and Inter-observer reliability low

Operative Treatment

- To expose the nerve or not expose the nerve
- Reduction methods
  - Clamp
  - Esmarch
  - K-wire
  - Dental pick

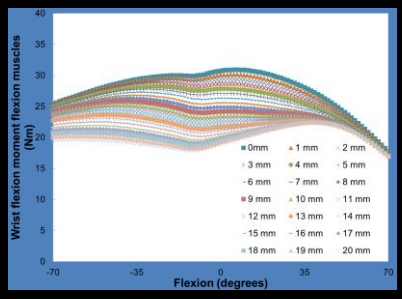


Fixation

- K-wires

- 4.0 or 4.5mm cannulated screws
- Suture anchors

Unpublished data



360 sports medicine

Rady Children's Hospital San Diego

Thank You

360 sports medicine

Rady Children's Hospital San Diego

Adolescent Clavicle Fractures: The Case for Non-Operative Treatment

John D. Polousky, MD
Surgical Director
Rocky Mountain Youth Sports Medicine Institute

Rocky Mountain Hospital for Children

Adolescent Clavicle Fractures: The Case for Non-Operative Treatment

John D. Polousky, MD

I have no conflicts

Rocky Mountain Hospital for Children

Midshaft Clavicle Fractures

- Children- Wide spread agreement for non-operative treatment.
- Management is controversial in adults- due to nonunion/symptomatic malunion.

Rocky Mountain Hospital for Children

What about adolescents?

- Nonunion-rare.
- Symptomatic malunion may be more common than once thought.
- First bone to ossify, last physis to close- 3rd decade.

Adolescent Clavicle Fracture

This is an enhanced PDF from The Journal of Bone and Joint Surgery
The PDF of the article you requested follows this cover page.

Nonoperative Treatment Compared with Plate Fixation of Displaced Midshaft Clavicular Fractures. A Multicenter, Randomized Clinical Trial

Canadian Orthopaedic Trauma Society
J Bone Joint Surg Am. 2007;89:1-10. doi:10.2106/JBJS.F.00020

Adolescent Clavicle Fracture

- Higher Constant and DASH scores in the operative group.
- Fewer Symptomatic Malunion 9/49 [non-op] vs. 0/62 [op].
- Fewer Nonunions [7/49 vs. 2/62].

Adolescent Clavicle Fracture

- What about the adolescents?
  - Nonunion is rare.
  - How frequent is symptomatic malunion?
  - Does remodeling correct some of the problems associated with malunion?
    - Strength.
    - Cosmesis.
    - Patient oriented outcomes.

Adolescent Clavicle Fracture

Operative Versus Nonoperative Treatment of Midshaft Clavicle Fractures in Adolescents

Kelly L. Vander Have, MD, Aaron M. Perdue, MD, Michelle S. Caird, MD, and Frances A. Farley, MD

(*J Pediatr Orthop* 2010;30:307–312)

Background: Midshaft clavicle fractures in adolescents have

Vander Have et al., JPO 2010

- Retrospective cohort [Level III].
- 42 patients with 43 clavicle fractures.
- Mean age 15.4 yrs.
- 25 nonoperative.
- 17 operative.

Vander Have et al., JPO 2010

- Non-operative group
  - 5 [20%] symptomatic malunions.
  - 4 elected corrective osteotomy, which alleviated sx.

Carry et al., JPO 2011

ORIGINAL ARTICLE

A Survey of Physician Opinion

Adolescent Midshaft Clavicle Fracture Treatment Preferences Among POSNA Members

Patrick M. Carry, BA, Ryan Koonce, MD,† Zhaoxing Pan, PhD,‡ and John D. Polousky, MD§*

Background: Based on recent evidence of inconsistent outcomes after the closed treatment of adult midshaft clavicle fractures, the management of similar fracture patterns in adolescents is being reevaluated. The primary aim of this study is to report current treatment preferences for adolescent midshaft clavicle fractures among pediatric orthopaedic physicians and to determine if recent adult literature has influenced clinical trials are needed to evaluate the efficacy of primary operative fixation of midshaft clavicle fractures in adolescent populations. **Level of Evidence:** Cross-sectional electronic survey; level V-expert opinion.

Key Words: adolescent, clavicle fracture, midshaft

(*J Pediatr Orthop* 2011;31:44-49)

Carry et al., JPO 2011

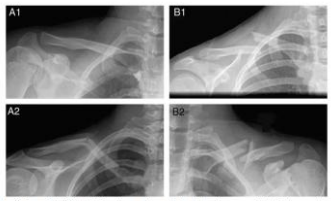


FIGURE 1. Radiographs of the midshaft clavicle fracture patterns included in the survey. The fracture patterns were chosen based on the Edinburg[2] classification system.

Carry et al., JPO 2011

- Even for segmental clavicle fractures in older adolescents, only 50% of POSNA members favored operative treatment.

POSNA 2012

- Paper #79 "Functional Outcomes after Adolescent Clavicle Fractures Based on Fracture Displacement and Age"
  - Reinerson, Priola, Wall, et al.

POSNA 2012

- Retrospective, min. 2 yr f/u.
- 91 pts. [age 10-18], treated nonoperatively.
- Compared degree of shortening with functional outcome.
- Functional outcomes [PODCI, QuickDASH] did not differ between shortening groups [0->2cm].

POSNA 2012

- Retrospective, min. 2 yr f/u.
- 91 pts. [age 10-18], treated nonoperatively.
- Compared degree of shortening with functional outcome.
- Functional outcomes [PODCI, QuickDASH] did not differ between shortening groups [0->2cm].

POSNA 2012

- Greater shortening was correlated with better sports and physical function.
- QuickDASH score decreased with age.
- PODCI not correlated with age/displacement/shortening.

POSNA 2012

- Paper #81 “Shoulder Motion, Strength and Functional Outcomes in Children with Established Malunion of the Clavicle”
  - Shah, Kalish, Kwon, Waters, **Bae**.
- 15 pts. with >2cm shortening, established malunion.

POSNA 2012

- Outcomes:

  PODCI, VAS, DASH, ROM, Strength.

  Forward flexion and abduction 6.5 degrees greater on uninjured side.

  Not clinically significant.

JBJS 2013

- Shulz, et al.
  - 16 pts. [14 +/- 2yrs]
  - 2 yrs. f/u
  - Injured vs. uninjured extremity.
  - All fractures "completely displaced and shortened"
  - Measured QuickDASH, strength, ROM.

JBJS 2013

- Shulz, et al.
  - Slight decrease external rotation strength [8%] and abduction endurance [11%].
  - No difference in QuickDash, all other strength and endurance measures.
  - All returned to previous level of activity, or higher.
  - 1 pt. dissatisfied with cosmesis.

14 yo male

2 yrs later

Conclusion

- Indications for ORIF:
  - Open fx.
  - Neurovascular compromise.
  - Impending skin compromise.
- ***Relative*** indications for ORIF:
  - Marked displacement?.
  - Polytrauma

Conclusion

Evidence to support the routine ORIF of displaced clavicle fractures in adolescents is lacking.

The available evidence demonstrates non-operative treatment of displaced clavicle fractures in adolescents generally produces excellent clinical results.

Clavicle Fractures in Adolescents – Operative Treatment

- Vumedi Webinar
- Nov 5, 2013
- Pediatric Adolescent Sports

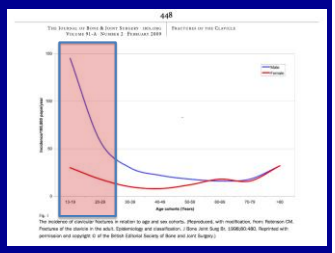
- Kevin G Shea, MD
- St. Lukes Sports Medicine
- St Lukes Health System
- Boise, Idaho

Disclosures

- None – Financial
- Reviewer
  - JPO
  - JBJS
  - CORR
- Committees
  - AAOS
  - AOSSM
  - POSNA

Epidemiology -

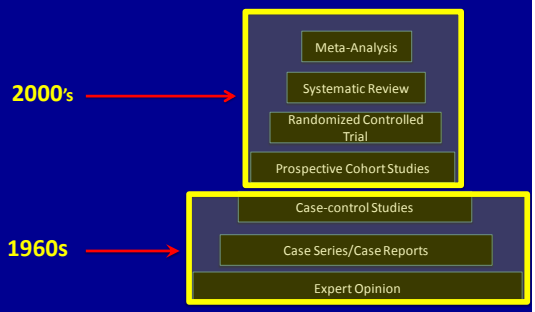
- 2.6-4.0% of all fractures
- 10-15% of all pediatric fractures
- Most Common fracture under 10 years of age
- This is a pediatric, adolescent, young adult male problem



Epidemiology: Location

- Mid-Shaft - 69 to 82%
  - Most are displaced

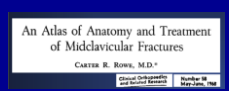
Study Designs – Levels of Evidence



History of Treatment – 1950-1990s

- Non-unions were thought to be rare for mid-shaft
  - 0.1% to 0.8%
- Mal-unions not discussed
- Open Treatment most common cause of Non-Union
  - Neer - 4.6%
  - Rowe - 3.7%
  - "The most common cause of non-union of fractures in the middle third has been improper initial operation ". . . Neer 1960


NONUNION OF THE CLAVICLE
Charles S. Neer II, M.D., New York

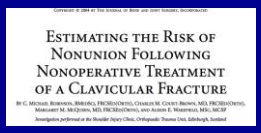

An Atlas of Anatomy and Treatment of Midclavicular Fractures
Carter R. Rowe, M.D.*

Clavicle Shortening and Poor Satisfaction

- Worse Clinical Results with Fracture Shortening
  - Ledger et al JSES 2005
  - Lazaridez et al JSES 2006

Some Real Data – Prospective, Registry

- Robinson et al 2004
- Risk Factors for Non-Union
  - Increasing Age
  - Female
  - Displacement
  - Comminution



ESTIMATING THE RISK OF NONUNION FOLLOWING NONOPERATIVE TREATMENT OF A CLAVICULAR FRACTURE

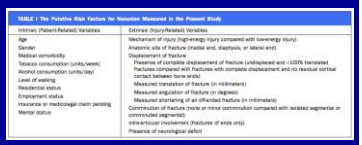
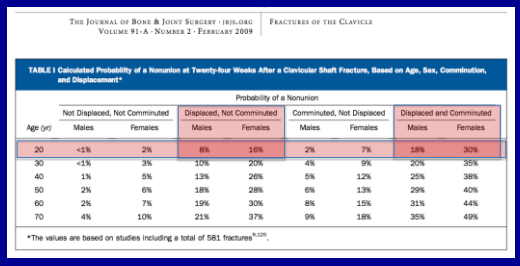


TABLE I The Putative Risk Factors for Nonunion Measured in the Present Study

Intrinsic (Patient-Related) Variables	Extrinsic (Injury-Related) Variables
Age	Mechanism of injury (high-energy injury compared with low-energy injury)
Gender	Anatomic site of fracture (medial end, diaphysis, or lateral end)
Medical comorbidity	Displacement of fracture
Tobacco consumption (units/week)	Presence of complete displacement of fracture (undisplaced and <100% translated fractures compared with fractures with complete displacement and no residual cortical contact between bone ends)
Alcohol consumption (units/day)	Measured translation of fracture (in millimeters)
Level of walking	Measured angulation of fracture (in degrees)
Residential status	Measured shortening of an offended fracture (in millimeters)
Employment status	Comminution of fracture (none or minor comminution compared with isolated segmental or comminuted segmental)
Insurance or medicolegal claim pending	Intra-articular involvement (fractures of ends only)
Mental status	Presence of neurological deficit

Data – A critical tool for patient centered care



THE JOURNAL OF BONE & JOINT SURGERY · JBJS.ORG | FRACTURES OF THE CLAVICLE
VOLUME 91-A · NUMBER 2 · FEBRUARY 2009

TABLE I Calculated Probability of a Nonunion at Twenty-four Weeks After a Clavicular Shaft Fracture, Based on Age, Sex, Comminution, and Displacement*

	Probability of a Nonunion							
	Not Displaced, Not Comminuted		Displaced, Not Comminuted		Comminuted, Not Displaced		Displaced and Comminuted	
Age (yr)	Males	Females	Males	Females	Males	Females	Males	Females
20	<1%	2%	8%	16%	2%	7%	18%	30%
30	<1%	3%	10%	20%	4%	9%	20%	35%
40	1%	5%	13%	26%	5%	12%	25%	38%
50	2%	6%	18%	28%	6%	13%	29%	40%
60	2%	7%	19%	30%	8%	15%	31%	44%
70	4%	10%	21%	37%	9%	18%	35%	49%

*The values are based on studies including a total of 581 fractures[9,12,25].

- Adolescent – 14-20 Year Age Group
- Displaced
- Displaced and Comminuted

Higher Quality Data - RCT

- McKee 2007 JBJS
- Operative versus non-operative
- Displaced Midshaft
- RCT - Adult males
- Operative Group
  - Improved functional Outcome
  - Lower rate of mal-union and nonunion


Nonoperative Treatment Compared with Plate Fixation of Displaced Midshaft Clavicular Fractures

A Multicenter, Randomized Clinical Trial

By the Canadian Orthopaedic Trauma Society

Adult Literature: 100% displaced mid-shaft clavicular fracture

- Obremsky, JBJS 2009
- 75% of all patients will do very well without surgery
- 25% of these clavicle fractures wont do well
  - Shortening, non-union, mal-union
- How do we determine which ones won't do well?

Systematic Review

- McKee et al 2012
- Meta-Analysis
- 6 Studies, 412 Patients
- Operative vs Non-operative
  - Non-union rate higher in non-operative group
  - 14.5 % vs 1.4 %
  - Symptomatic Mal-union rate higher in non-op
  - 8.5 % vs. 0.0%
- Earlier Functional Recovery in operative group
- No evidence to support better long term outcomes in operative group


Operative Versus Nonoperative Care of Displaced Midshaft Clavicular Fractures: A Meta-Analysis of Randomized Clinical Trials

Where are we now?

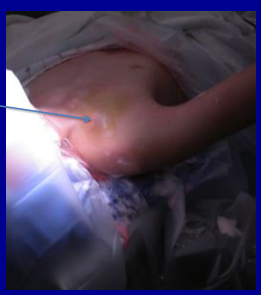
- Displaced, comminuted fractures
- We have much better evidence for decision making in adults
- Non-operative treatment is an option
- Some non-unions have good shoulder function

Where are we now?

- Displaced, comminuted fractures
- Active adults may do better with surgery? 6 months only?
- Shortening – association with poor satisfaction
- Healing Rate in the skeletally immature is still not known

Surgical Indications

- Skin tenting
- Open fractures
- Soft-tissue interposition
- Neurovascular compromise
- Multiple trauma
- Floating shoulder



Relative Surgical Indications

Patient Centered Decision Making is Key

- Younger, active patients with greater than 1.5-2 cm of shortening
- Severe displacement or comminution
- Significant cosmetic deformity
- Work, Sports
  - Cyclists
- Hand dominance

Case Discussions

Treatment for Mid-Shaft Fractures Minimally Displaced

- Non-displaced or minimally displaced
- Non-Operative Treatment
- Remains non-controversial

15 Year old Male Clavicle Fracture

3 Weeks

10 weeks

Case Study: Radiographs

13 Year old Male
Closed fracture
Soccer
Non skin compromise

How would you treat this?

Treatment Options

- 1. Sling
- 2. Figure 8 Brace
- 3. Closed Reduction
- 4. Open reduction with Plate
- 5. Open reduction with IM Rod

Now 17 Years Old – Chronic Shoulder Pain, and weakness

Treatment Options

- 1. Sling
- 2. Figure 8 Brace
- 3. Closed Reduction
- 4. Open reduction with Plate
- 5. Open reduction with IM Rod

ORIF with Local Bone Graft