

Paediatric Anterior Cruciate Ligament Rupture

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Key Learning Objectives

- * Why is there an increasing incidence of ACL rupture amongst young people?
- * What is the goal of ACL reconstruction surgery?
- * Why is ACL reconstruction different in younger patients?
- * Non-surgical treatment outcomes
- * Evidence for ACL injury prevention programs



Health

ACL reconstructions up more than 70 per cent among young Australians, study finds



ABC Health & Wellbeing By health reporter [Olivia Willis](#) and [Tegan Taylor](#)

Posted 23 April 2018 at 12:02 am



Sports where players change direction at speed, such as soccer, are associated with knee injuries. (936 ABC Hobart: Damien Peck/file photo)

Knee reconstructions for young Australians are on the rise, posing an expensive and painful public health problem in the future, a new study has found.



ROYAL AUSTRALASIAN COLLEGE OF SURGEONS

MEDIA RELEASE



Safe Sport for Kids – Over 50% of ACL knee injuries are preventable

Tuesday 3 May 2016

Australia has the highest incidence of anterior cruciate ligament (ACL) injuries in the world, and sports injuries are now the number one reason for youth admission to hospital, surgeons at the Royal Australasian College of Surgeons (RACS) Annual Scientific Congress (ASC) have been told in Brisbane.

Head of the Musculoskeletal Research Program at Griffith University in Queensland Professor David Lloyd told the conference that the Australian Football League (AFL) had supported research to develop a range of injury prevention strategies.

“Our studies, and those of others, consistently revealed the causes ACL injuries from which we then developed interventions,” Prof Lloyd said.

“ACL ruptures commonly occur during non-contact side stepping or when landing from a mark during AFL and other sports when stepping”.

“Our laboratory studies and computer simulations have shown that specific technique and aggressive balance training prevent knee injury”.

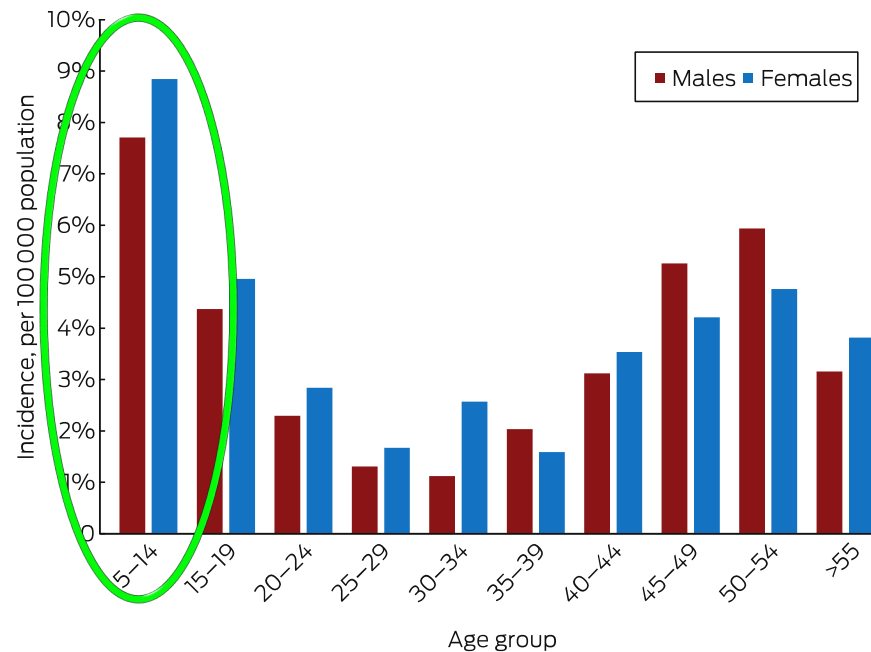
“Using this evidence we have developed training programs to prevent ACL and lower limb joint injuries in community level Australian Football. In a randomised placebo control trial in over 1600 Australian Football players we were able to reduce the relative risk of these in-game knee injuries by 50 per cent.

Queensland Orthopaedic Surgeon, Chair of the AOA Youth Sports Injury Prevention Working Group and knee specialist Associate Professor Christopher Vertullo, who is also presenting to the ASC on ACL injuries, told surgeons that ACL injury patients were at risk of developing premature knee osteoarthritis (OA) and resultant later severe disability, despite it being a highly preventable injury.

“Direct health costs from ACL injury include reconstruction surgery, non-operative osteoarthritis management and eventual knee replacement. The most popular Australian sports such as a AFL, Rugby League, Rugby Union, Touch Football and Netball are all high risk for knee injury.”
A/Professor Vertullo said that over 50 per cent of ACL injuries were preventable by a regular

Australian trends

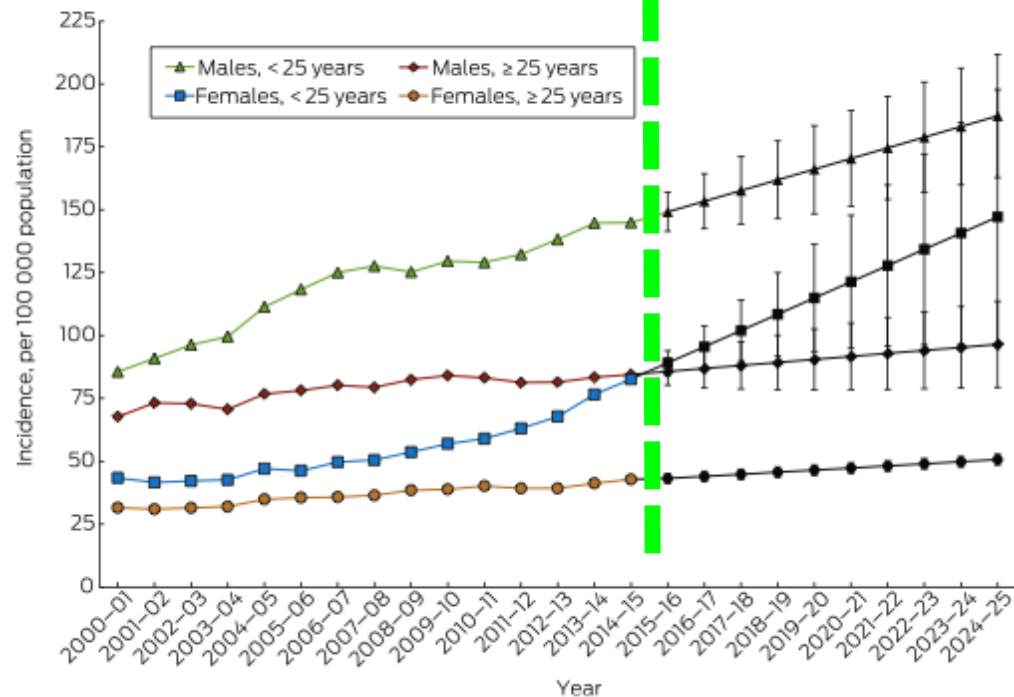
4 Annual growth in the incidence of primary anterior cruciate ligament reconstruction, 2000–2015, by sex and age group



Annual growth of ACL surgery performed in Australia.
(Zbrojkiewicz et al, MJA 2018)

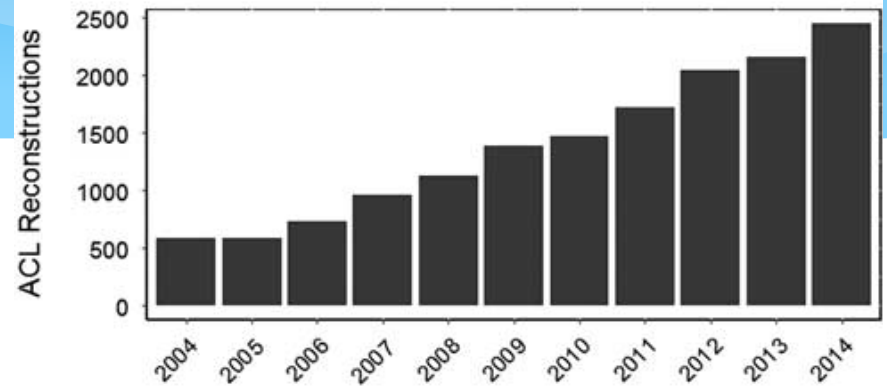
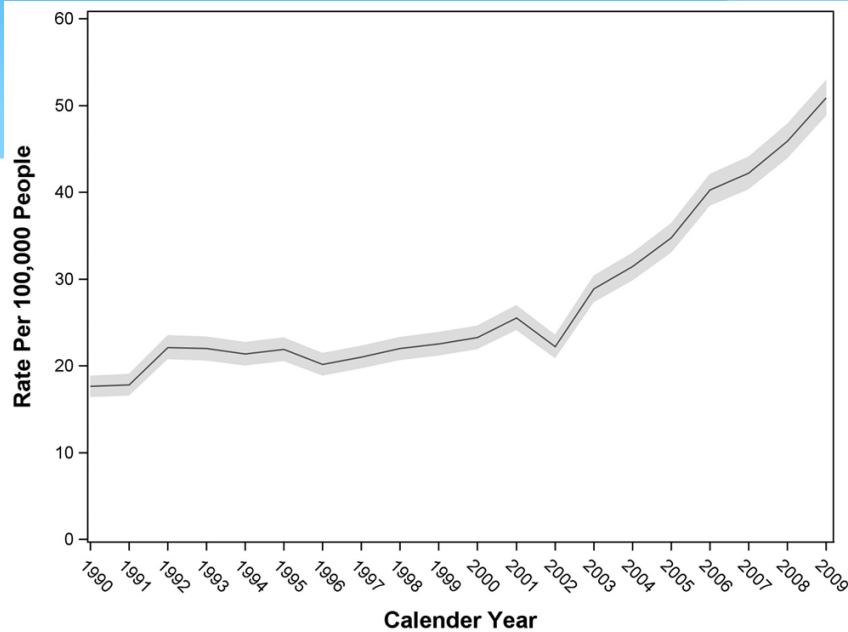
Australian trends

6 Incidence of primary anterior cruciate ligament reconstruction in Australia, 2000–2015, by sex and broad age group



(Zbrojkiewicz et al, MJA 2018)

International trends



Annual rate of ACL surgery performed in Paediatric Institutions has increased **3 fold during the 10 year period** studied by Harvard. (Tepolt et al, JPO 2018)

Issues

- * There is a rising incidence of ACL rupture in the paediatric and adolescent population.
- * Treatment of this condition is complicated by growing bones, challenges with treatment compliance and higher re-injury rates
- * There is unanimous agreement that prevention tools are required

Why ACL in Young People?



Participation



Screen time



Female participation



Training intensity

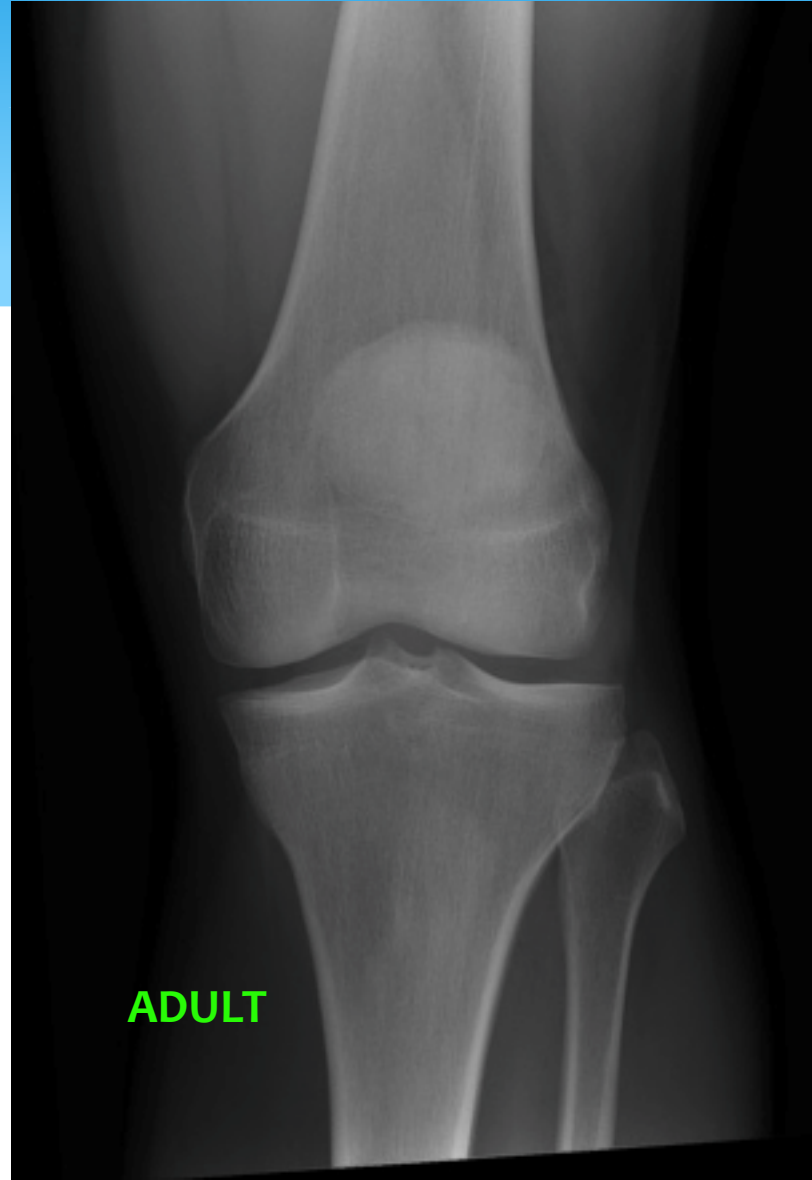


Less free play



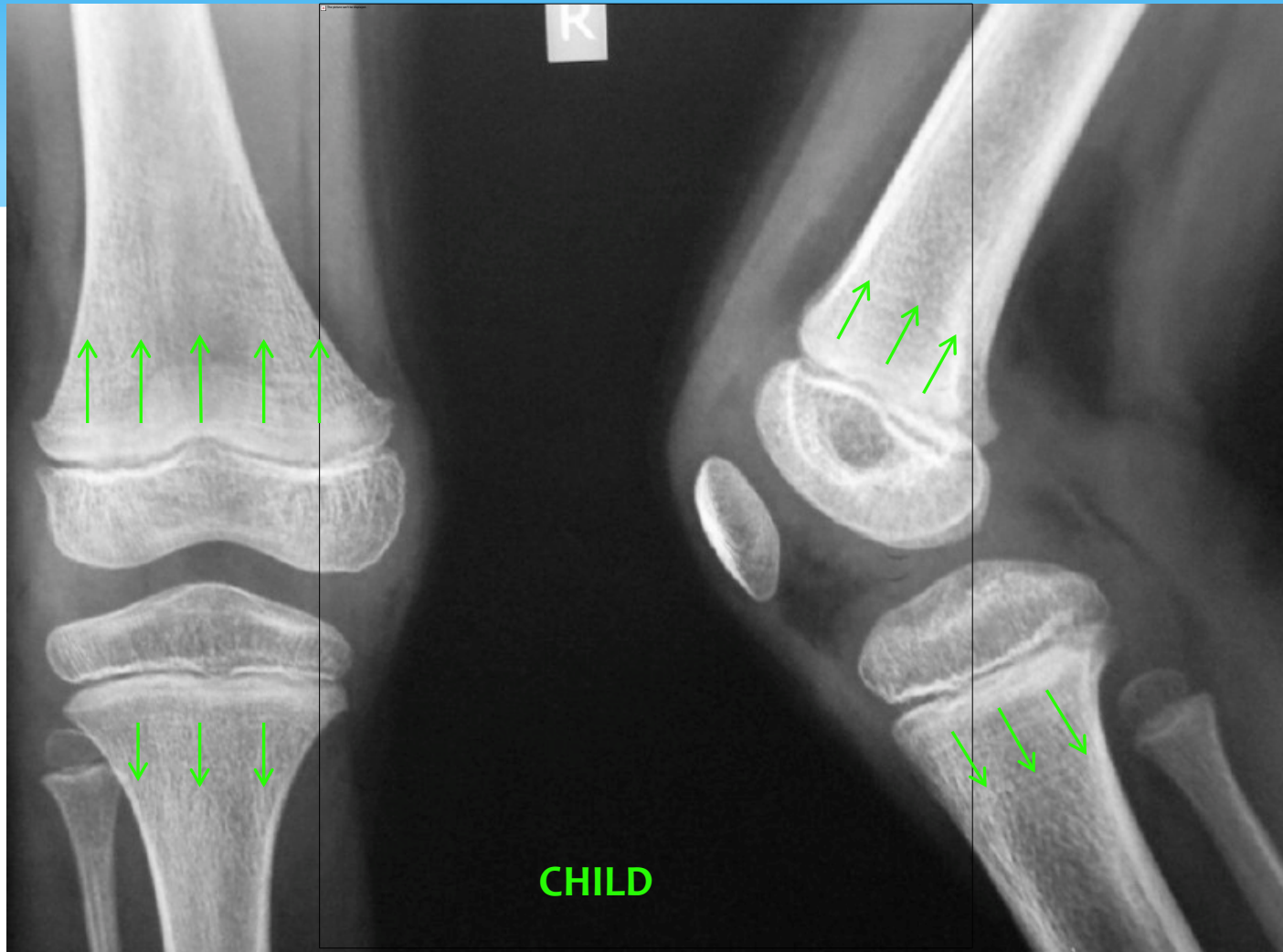
Imaging access

Anatomical Paediatric Consideration



ADULT

Anatomical Paediatric Consideration



Considerations in Young Patients

- * Behaviour & Functional requirements (differ from adults)
- * Growing Bones
- * Ligamentous Laxity (higher failure rate)
- * Surgical Options
- * Higher rates of re-rupture after ACL reconstruction
- * ACL Rupture Injury Prevention





Unlikely to restrict sporting & pivoting activities

Sport is key to self identity

High risk of re-injury

Sport not key to income

More likely to consider modifying sporting activities

Sport is not key to income

Lower risk of re-injury

Likely to be compliant with strict rehabilitation program

Unable to restrict pivoting activities

Sport is key to self identity

High risk of re-injury

Sport is key to income

Likely to be compliant with strict rehabilitation program

WHY RECONSTRUCT ACL?



Goals of ACL Recon?



- * Allow return to high demand activities
 - Occupation
 - Recreation (sports)
- * Prevent Instability with ADLs
- * Prevent ongoing damage to meniscus
- * Prevent ongoing damage to cartilage



From the Department of Orthopedics, Clinical Sciences Lund, Lund University, Lund, Sweden (R.B.F., H.P.R., J.R., L.S.L.); and the Institute of Sports Science and Clinical Biomechanics, University of Southern Denmark, Odense, Denmark (E.M.R.). Address reprint requests to Dr. Frobell at the Department of Orthopedics, Lund University Hospital, SE-22185 Lund, Sweden, or at richard.frobell@med.lu.se.

This article (10.1056/NEJMoa0907797) was updated on August 25, 2010, at NEJM.org.

N Engl J Med 2010;363:331-42.

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The NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

A Randomized Trial of Treatment for Acute Anterior Cruciate Ligament Tears

Richard B. Frobell, Ph.D., Ewa M. Roos, P.T., Ph.D., Harald P. Roos, M.D., Ph.D., Jonas Ranstam, Ph.D., and L. Stefan Lohmander, M.D., Ph.D.

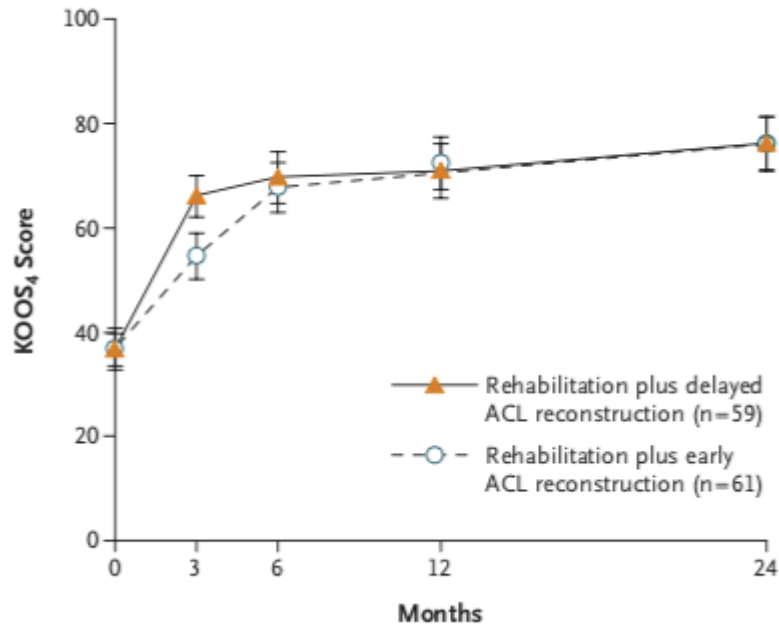
N = 63 assigned to rehab and early ACL Recon

N = 59 assigned to rehab plus option of delayed ACL Recon
(23 underwent delayed ACL Recon)

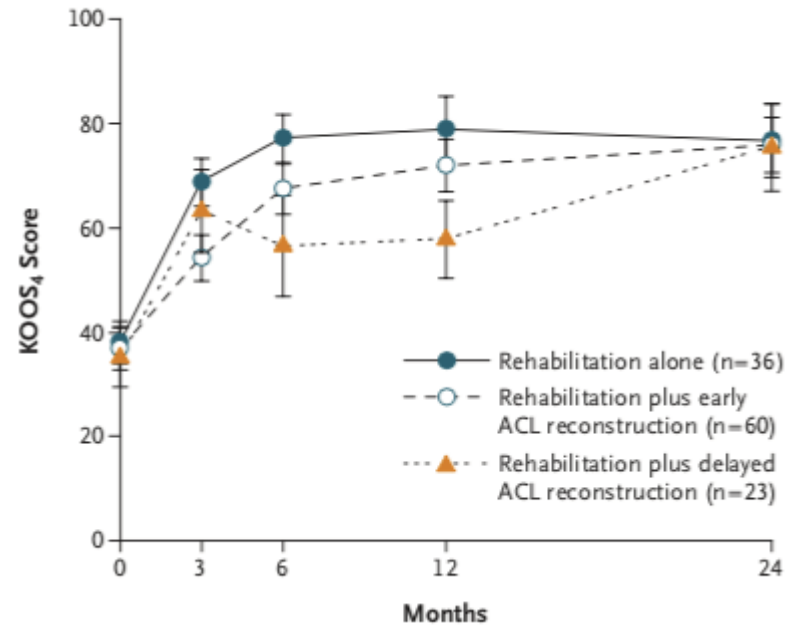
Exclusions:

- <18 yrs, >35 yrs
- Professional athletes
- Chondral lesions
- Unstable meniscal tears
- Meniscal debridement
- MCL / LCL tear on MRI

A Full Analysis



B Post Hoc As-Treated Analysis



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What about non-surgical ACL management in Kids?

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EXHIBIT SELECTION

Reconstruction of the Anterior Cruciate Ligament in the Skeletally Immature Athlete: A Review of Current Concepts

AAOS Exhibit Selection

Peter D. Fabricant, MD, Kristofer J. Jones, MD, Demetris Delos, MD, Frank A. Cordasco, MD, MS, Robert G. Marx, MD, MSc,
Andrew D. Pearle, MD, Russell F. Warren, MD, and Daniel W. Green, MD, MS

Investigation performed at the Hospital for Special Surgery, New York, NY

*Increased healing potential in children & risk of
physeal damage with surgery has made non surgical
management appealing*

*However, clinical outcomes following non-surgical
treatments have not been favourable*

Partial ACL Injuries in Kids

Non-surgical management is recommended in patients with:

- <50% partial ACL tear on MRI
- Normal Lachman's & Pivot Shift test

Complete ACL Ruptures in Kids

- Universally poor outcomes
- 50% do not return to any form of athletic activity
- Clinical instability leads to progressive meniscal and cartilage damage in 61% of cases



Anterior Cruciate Ligament Tears in Children and Adolescents



A Meta-analysis of Nonoperative Versus Operative Treatment

David E. Ramski,^{*} MD, Wajdi W. Kanj,^y MD, Corinna C. Franklin,^z MD,
Keith D. Baldwin,[§] MD, MSPT, MPH, and Theodore J. Ganley,^{§k} MD
Investigation performed at the Department of Orthopaedic Surgery,
The Children's Hospital of Philadelphia, Philadelphia, Pennsylvania

Non-surgical Treatment Groups

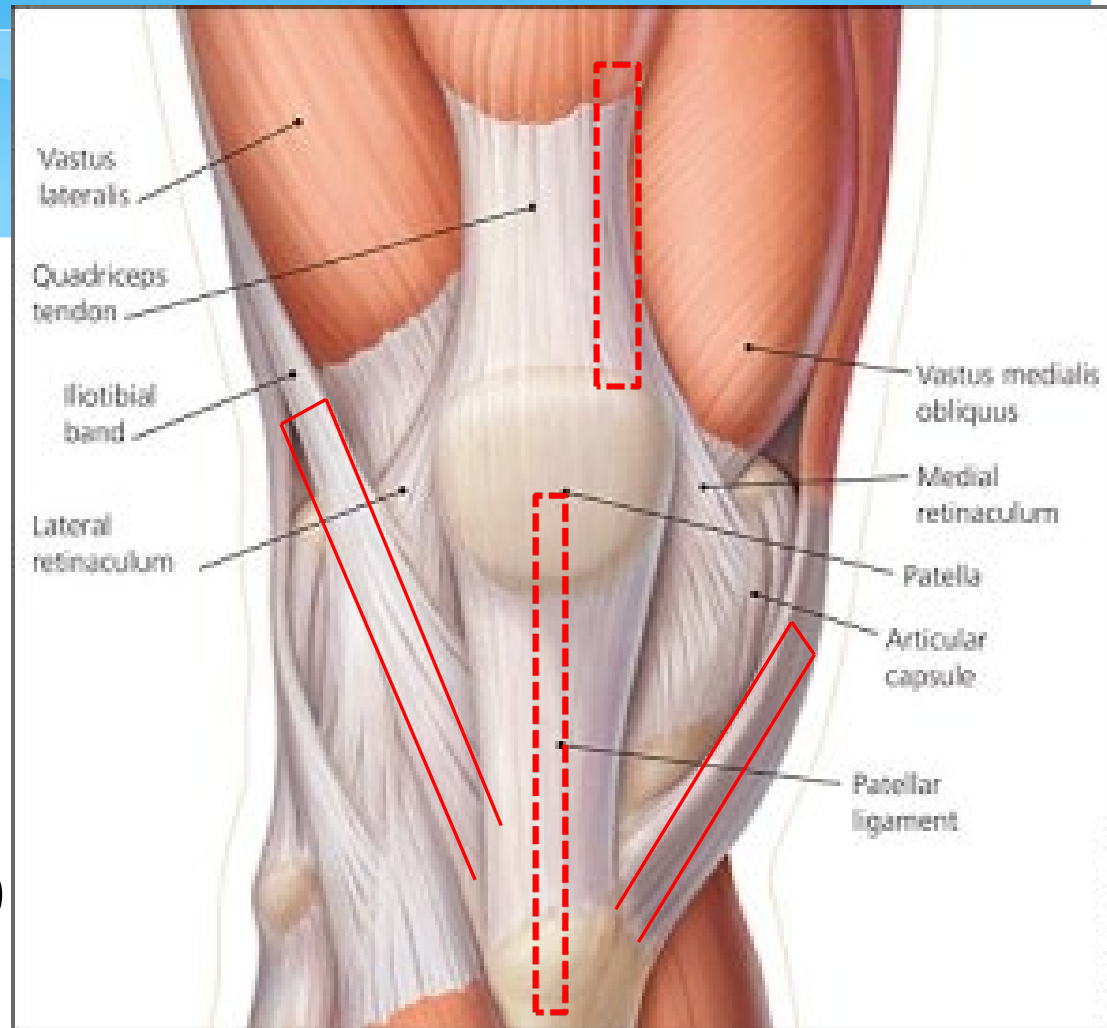
- 75% Residual instability or pathological laxity
- 35% rate of subsequent medial meniscal tear
- Lower IKDC & Tegner scores
- 0% return to previous level of sport

Surgical ACL Reconstruction Groups

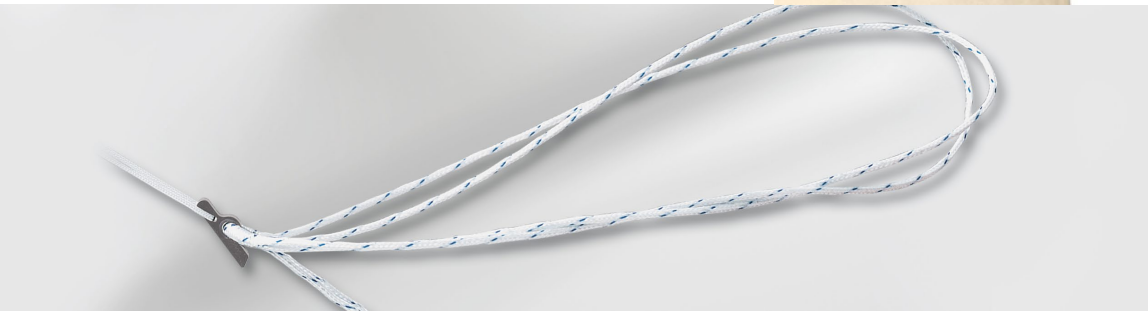
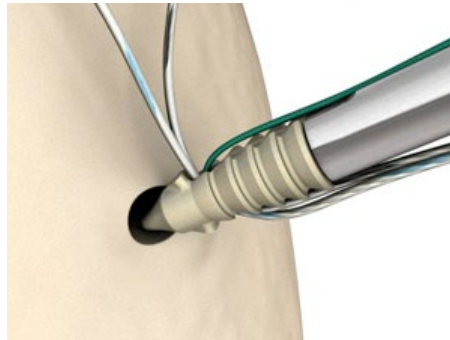
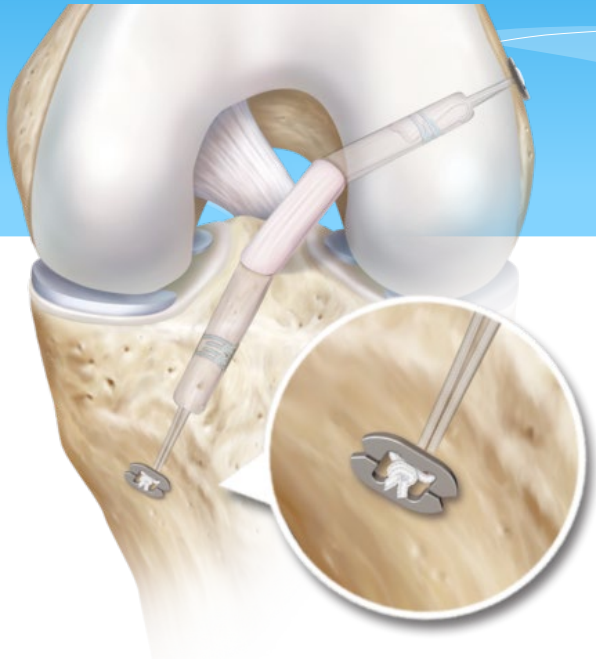
- 13% Residual instability or pathological laxity
- 4% rate of subsequent medial meniscal tear
- Higher IKDC & Tegner scores
- 85% return to previous level of sport

Surgical Options

- * Graft Choices
 - * (see image)
- * Fixation choices
 - * Suspensory
 - * Aperture (interference)



Fixation Choices



ACL INJURY TREATMENTS



TRANSPHYSEAL SURGERY



PARTIAL TRANSPHYSEAL SURGERY



PHYSEAL SPARING SURGERY (ANDERSON TECHNIQUE)

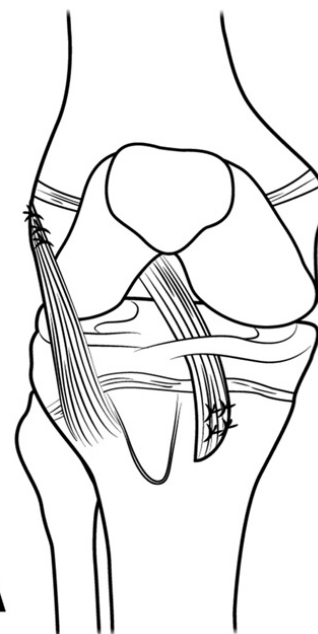


PHYSEAL SPARING SURGERY (MICHELI-KOCHER TECHNIQUE)

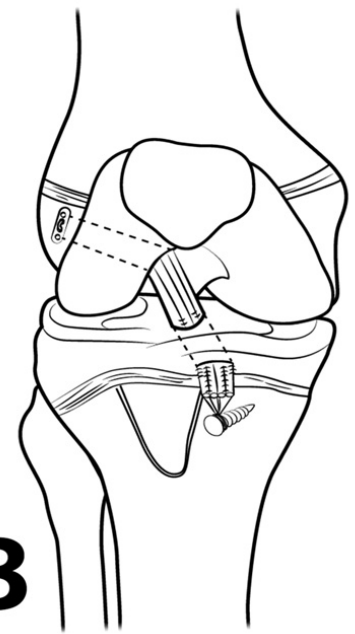


NON-OPERATIVE

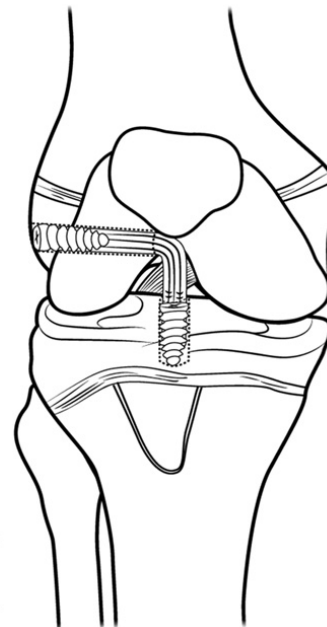
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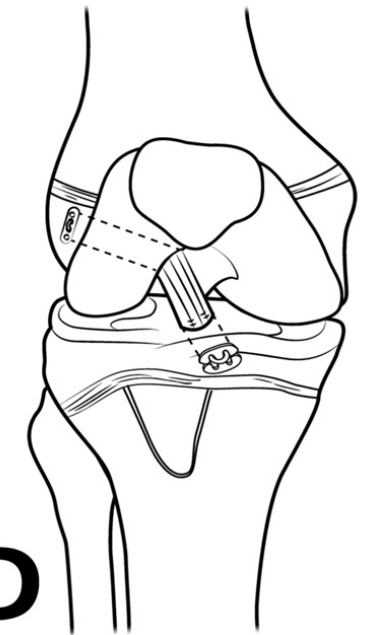
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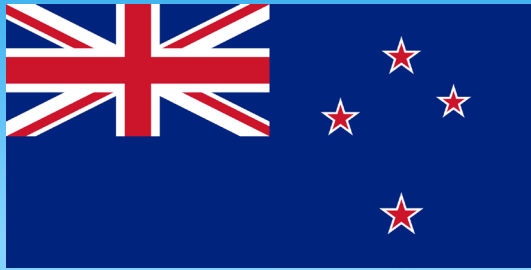
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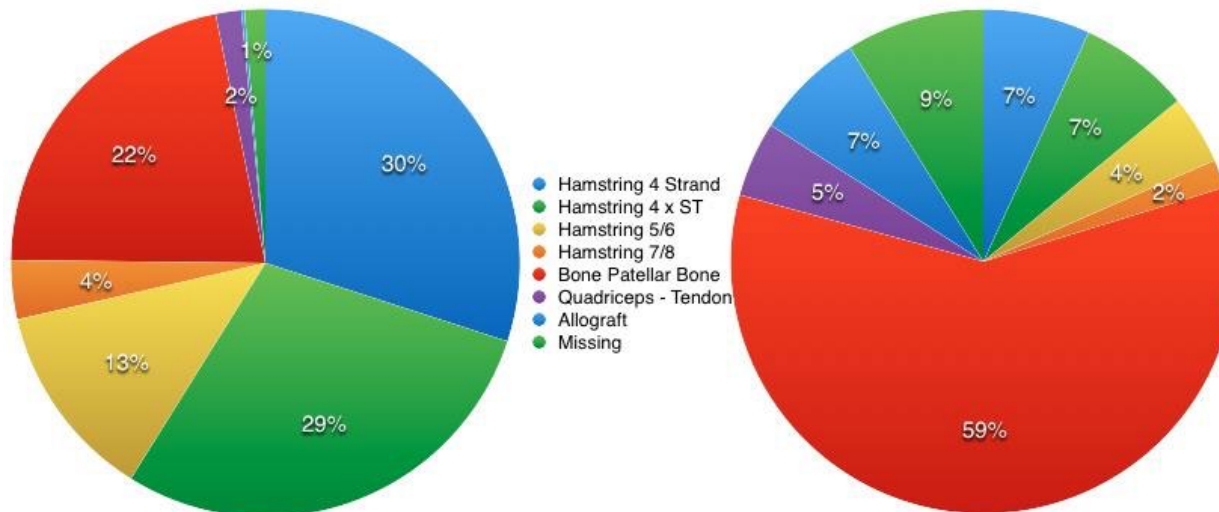


NZ ACL 2019 Registry Data



Graft Choice:

For primary ACL reconstruction, the predominant graft choice is hamstring, accounting for 73.5% of all primary ACLs. 30% are 4 strand grafts with semitendinosus and gracilis. The majority of the others are quadrupled semitendinosus grafts (29%), although there is a trend for an increasing use of 6 to 8 strand grafts (17%). BTB is the next most popular graft, making up 21.4% of primary ACLs.



Graft choice: Primary

Graft choice: Revision

Risk Factors and Predictors of Subsequent ACL Injury in Either Knee After ACL Reconstruction

Prospective Analysis of 2488 Primary ACL Reconstructions From the MOON Cohort

Christopher C. Kaeding,^{*yz} MD, Angela D. Pedroza,^y MPH, Emily K. Reinke,[§] PhD, Laura J. Huston,[§] MS, MOON Consortium,[†] and Kurt P. Spindler,^{||} MD
Investigation performed at the Ohio State University, Columbus, Ohio, USA, and Vanderbilt University Medical Center, Nashville, Tennessee, USA

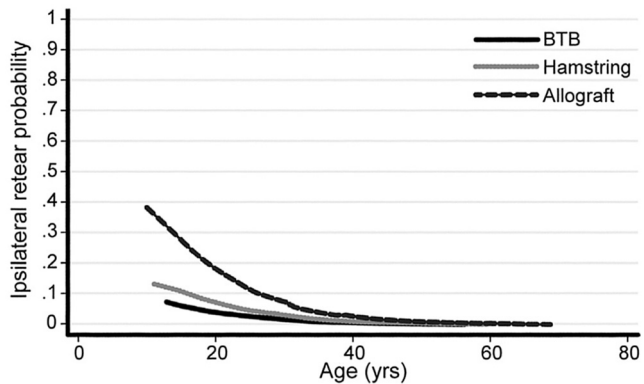
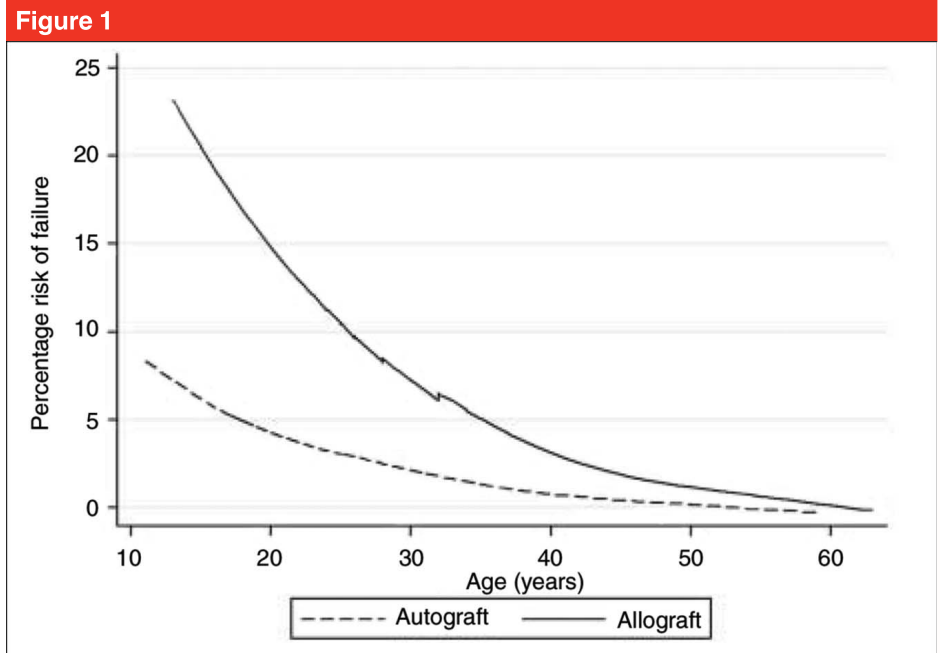
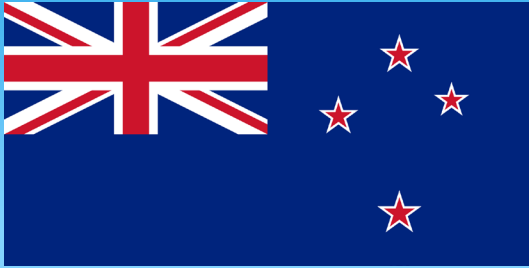


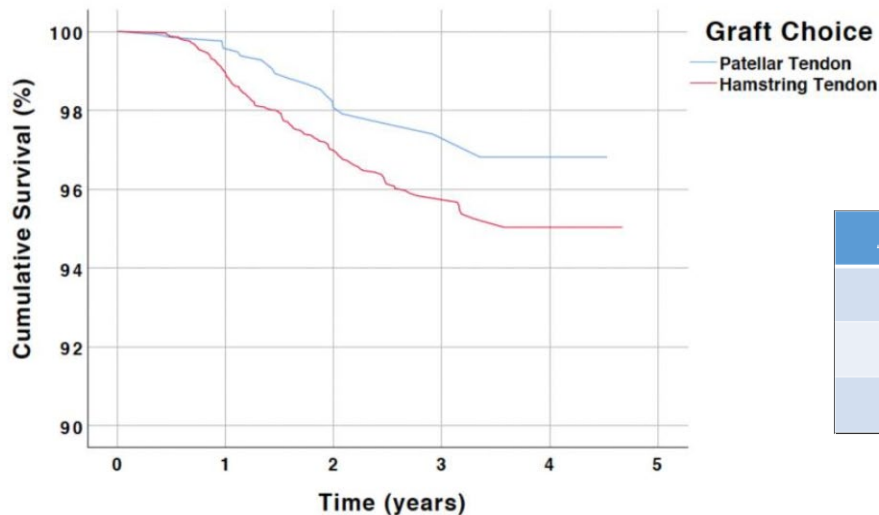
Figure 2. Probability of retear as age increases by graft type.



NZ ACL 2019 Registry Data



Patella Tendon vs Hamstring Graft Re-rupture after Primary ACL Reconstruction (2019)



Age group	BTB	HS
< 20y	2.7%	12.4%*
20 – 24y	4.3%	10.3%**
25+	0.9%	3.8%

* p = 0.02
** p = 0.03

Scandinavian ACL Registries

Lower Risk of Revision With Patellar Tendon Autografts Compared With Hamstring Autografts

A Registry Study Based on 45,998 Primary ACL Reconstructions in Scandinavia

Tone Gifstad,^{*,y,z} MD, PhD, Olav A. Foss,^{y,z} MD, PhD, Lars Engebretsen,[§] MD, PhD, Martin Lind,^k MD, PhD, Magnus Forssblad,^l MD, PhD, Grethe Albrektsen,^z PhD, and Jon Olav Drogset,^{y,z} MD, PhD
Investigation performed at Trondheim University Hospital, Trondheim, Norway

Background: A number of studies have found comparable results after anterior cruciate ligament (ACL) reconstruction with patellar tendon autografts and hamstring autografts; however, few studies have been large enough to reveal differences in risk of revision with regard to clinical and demographic factors.

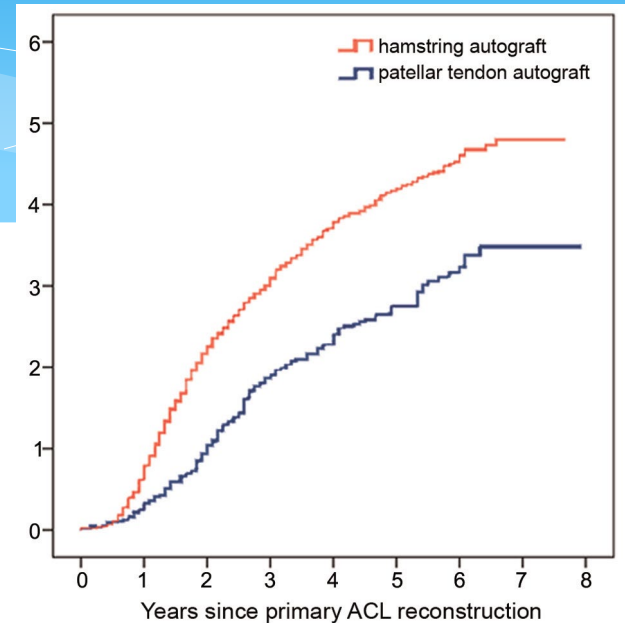
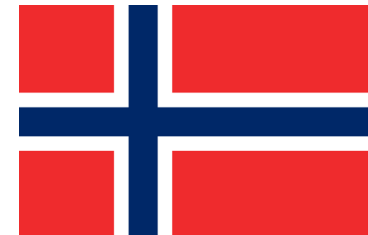


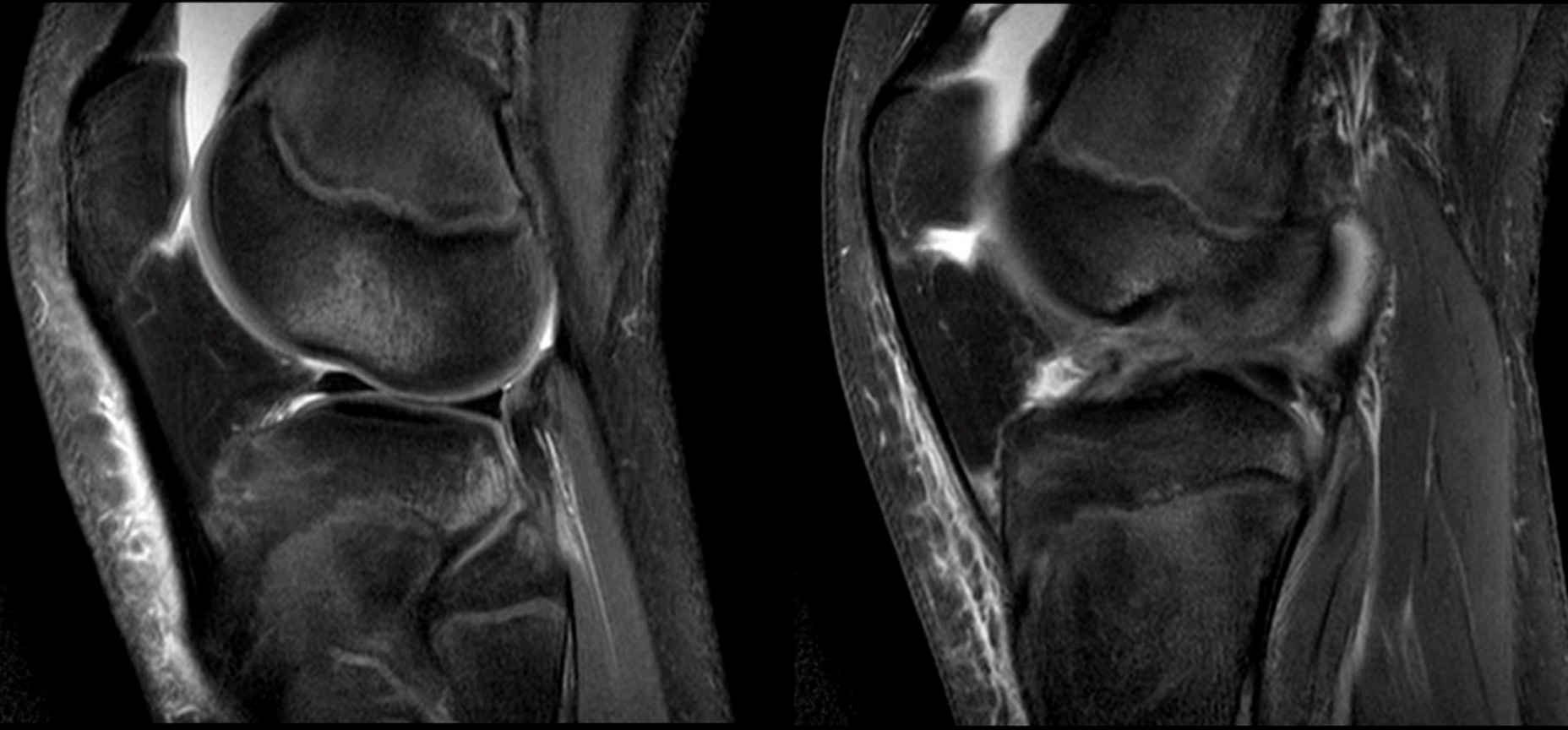
TABLE 2
Distribution of Clinical and Demographic Factors at Primary ACL Reconstruction in Patients Receiving Patellar Tendon or Hamstring Autografts (N = 45,402)^a

	Patellar Tendon Autograft (n = 22,666)	Hamstring Autograft (n = 22,736)
Age at surgery, y		
<15	57 (<1.0)	1141 (3.0)
15-19	1378 (20.5)	9569 (24.7)
20-24	1222 (16.9)	7988 (23.9)
25-29	1084 (16.1)	5618 (14.5)
30-34	903 (13.4)	4568 (11.8)
35-39	854 (12.7)	4239 (11.0)
40-44	643 (9.5)	3430 (8.9)
≥45	591 (8.8)	2809 (7.3)

ilities.

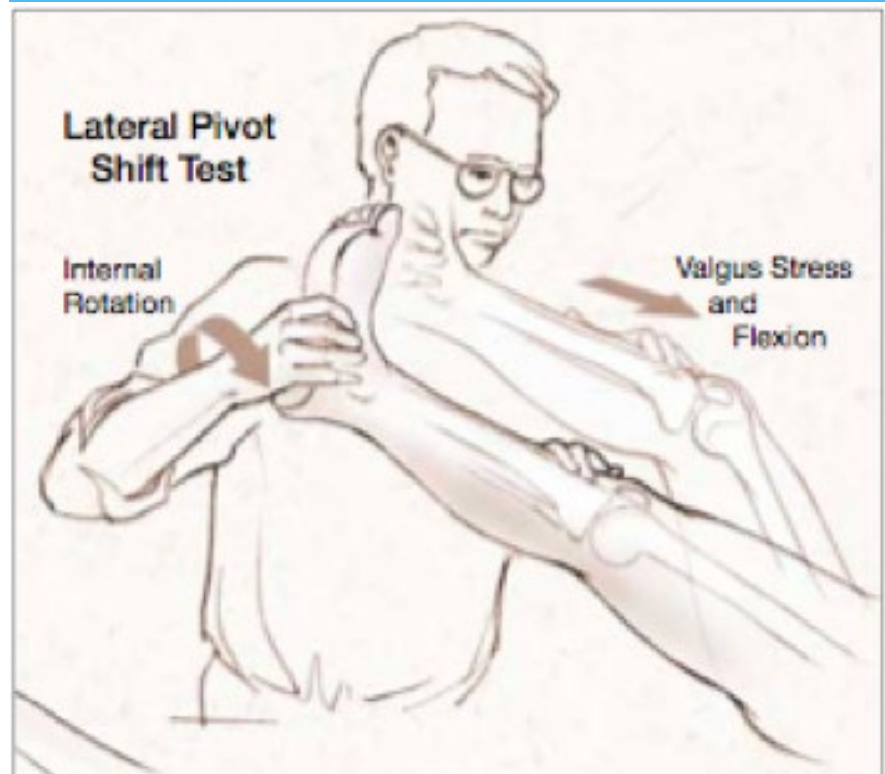


What is the Pivot Shift?



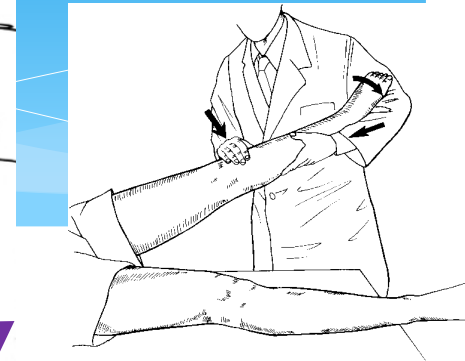
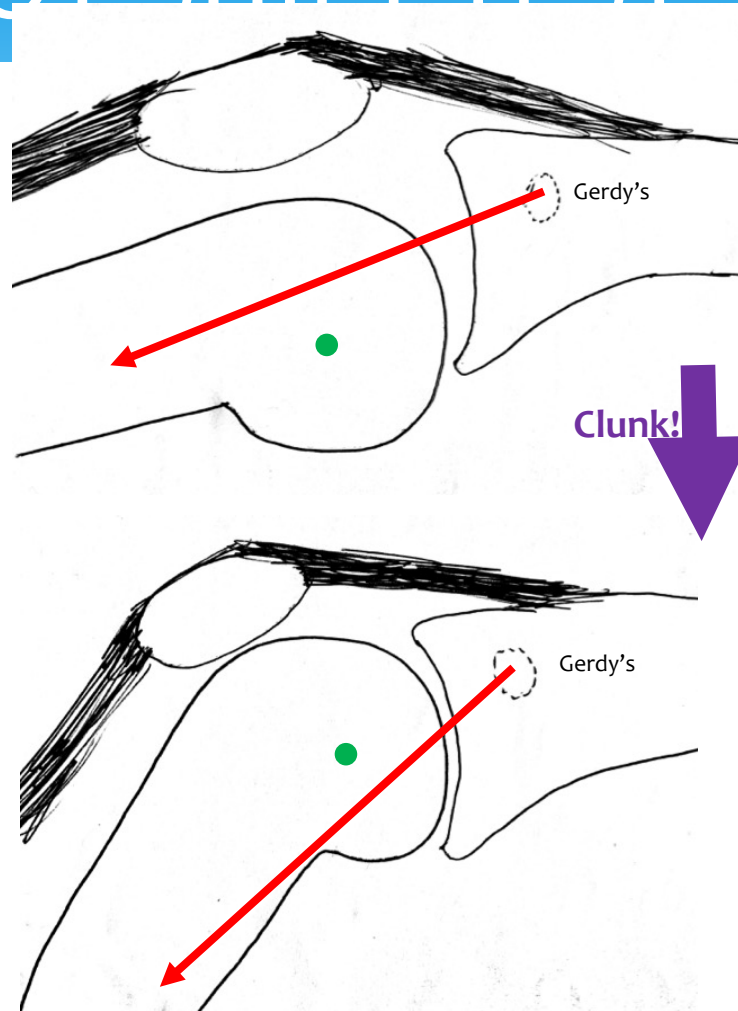
PIVOT SHIFT TEST

1. Start with knee held elevated by foot, muscles relaxed
 2. INTERNALLY rotate the tibia (in the ACL deficient knee the LFC subluxes posteriorly against the LTP).
 3. SLOWLY FLEX the knee up
 4. As the knee flexes, ITB will pass from anterior to posterior relative the centre of knee flexion.
 5. The subluxed lateral compartment will REDUCE WITH A PALPABLE JUMP or CLUNK
 6. This is a positive test
- * TIPS:
 - * Accentuate the CLUNK by
 - i) Adducting the leg from hip (tightens ITB)
 - ii) Applying axial load via foot
 - iii) Apply valgus load at knee

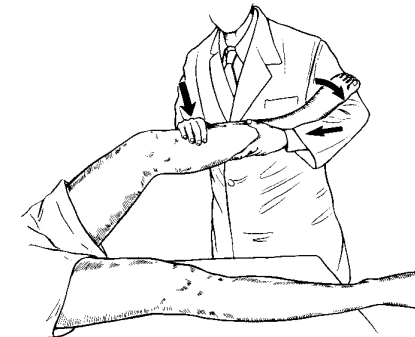


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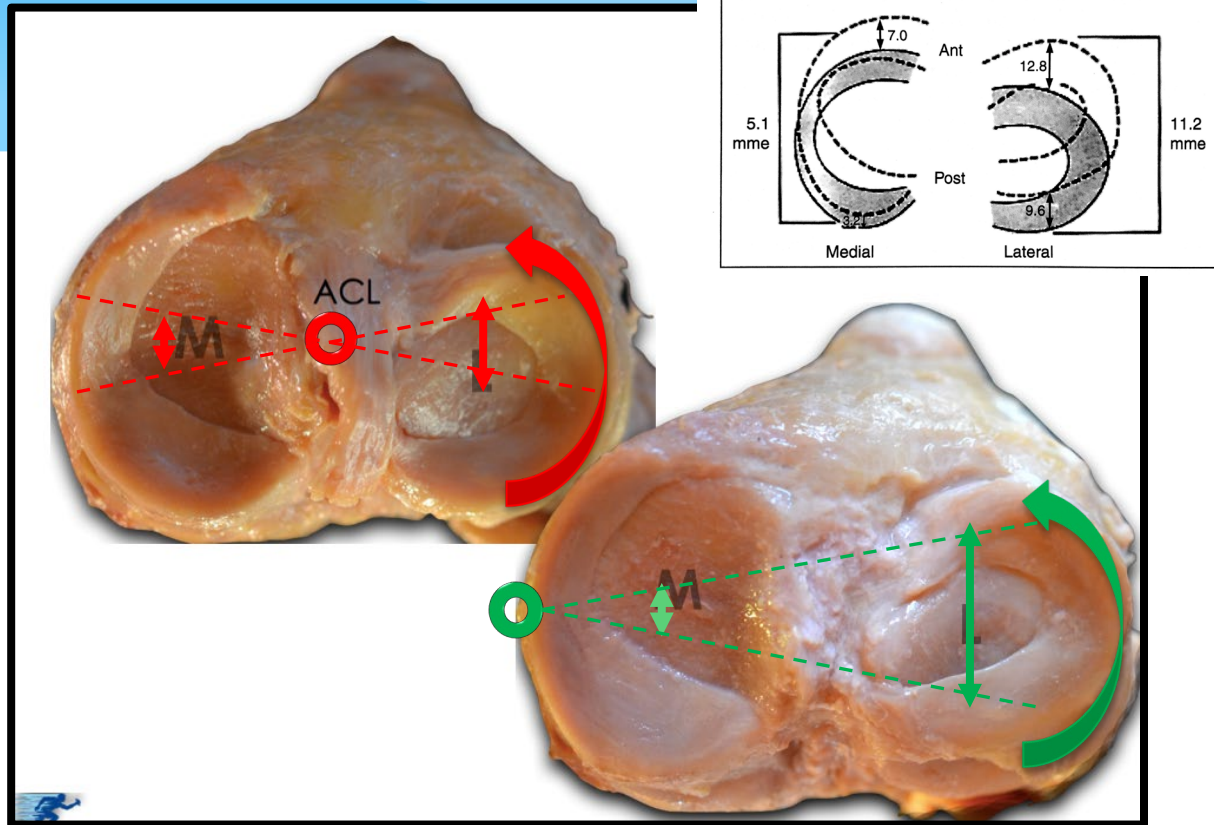


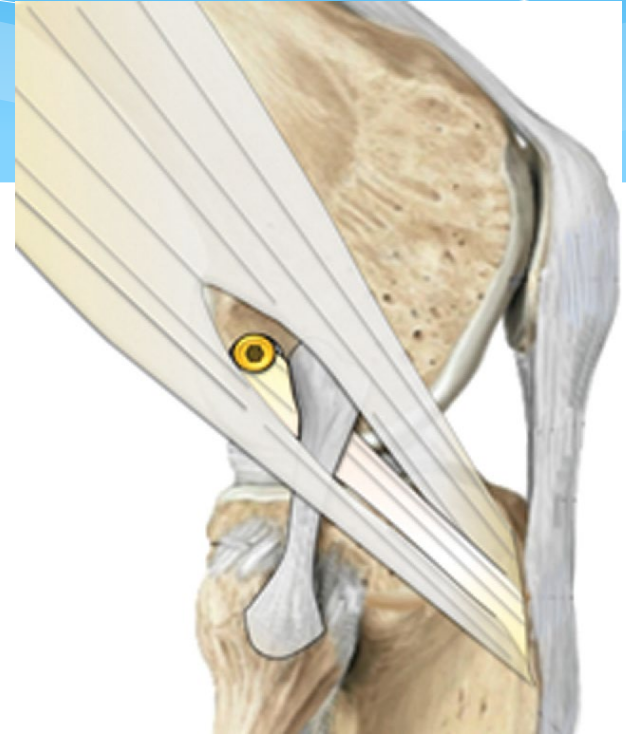
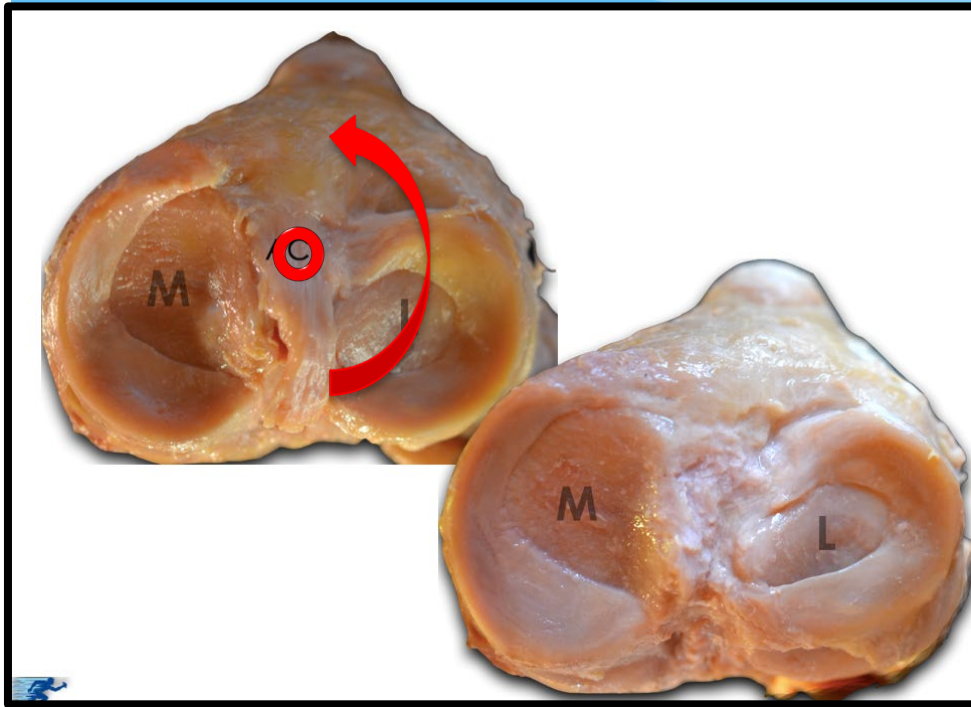
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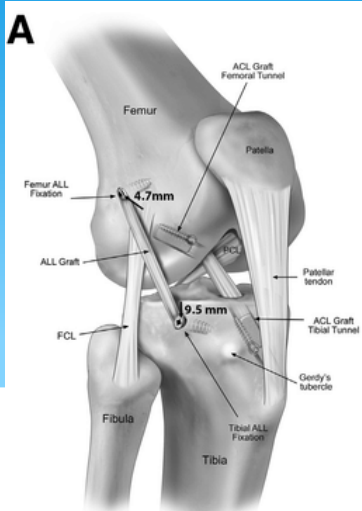


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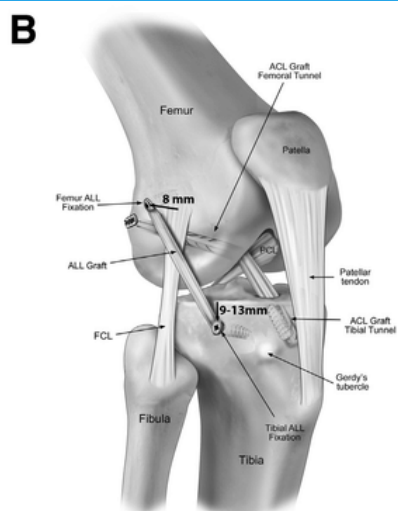
Pivot Shift



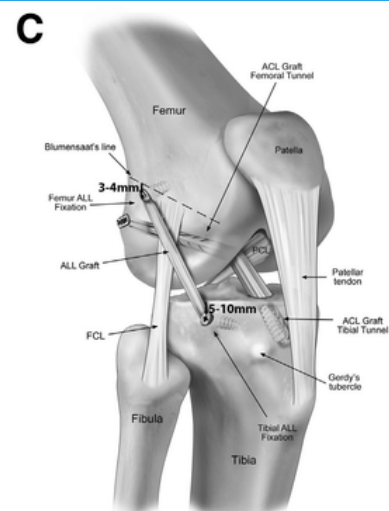




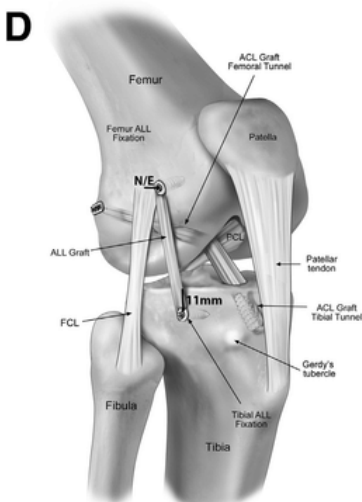
Chahla et al



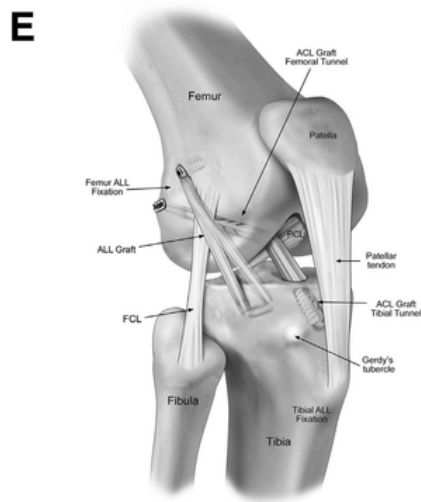
Ferreira et al



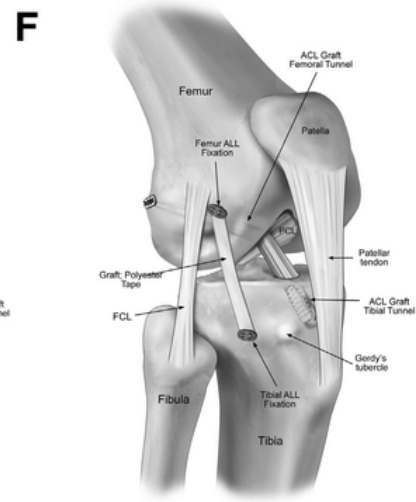
Helito et al



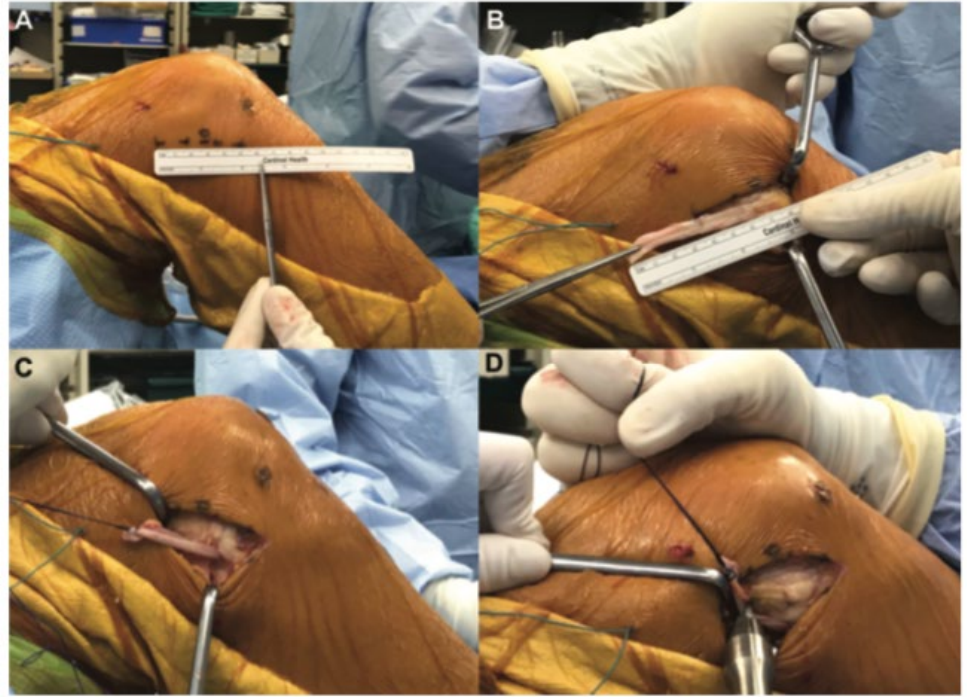
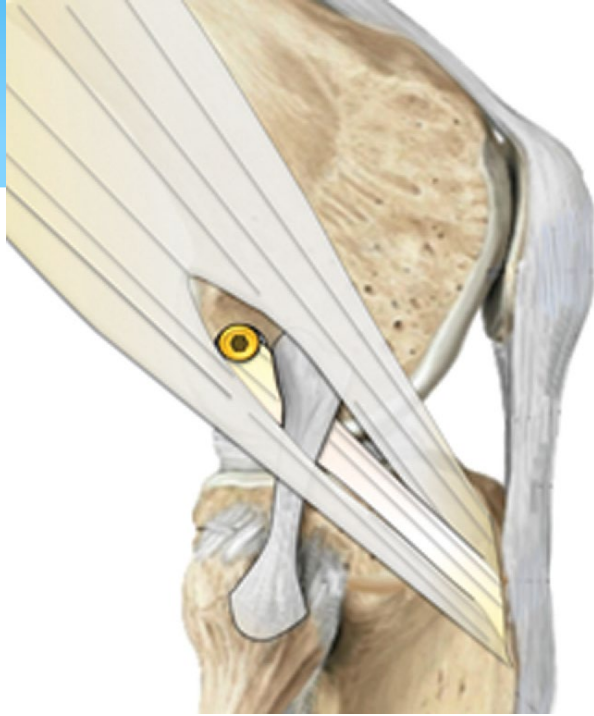
Smith et al



Sonnery-Cottet et al



Wagah et al



Winner of the O'Donoghue Sports Injury Award

Lateral Extra-articular Tenodesis Reduces Failure of Hamstring Tendon Autograft Anterior Cruciate Ligament Reconstruction



2-Year Outcomes From the STABILITY Study Randomized Clinical Trial

Results: A total of 618 patients (297 males; 48%) with a mean age of 18.9 years (range, 14-25 years) were randomized. A total of 436 (87.9%) patients presented preoperatively with high-grade rotatory laxity (grade 2 pivot shift or greater), and 215 (42.1%) were diagnosed as having GLL. There were 18 patients lost to follow-up and 11 who withdrew (~5%). In the ACLR group, 120/298 (40%) patients sustained the primary outcome of clinical failure, compared with 72/291 (25%) in the ACLR+LET group (relative risk reduction [RRR], 0.38; 95% CI, 0.21-0.52; $P < .0001$). A total of 45 patients experienced graft rupture, 34/298 (11%) in the ACLR group compared with 11/291 (4%) in the ACL+LET group (RRR, 0.67; 95% CI, 0.36-0.83; $P < .001$). The number needed to treat with LET to prevent 1 patient from graft rupture was 14.3 over the first 2 postoperative years. At 3 months, patients in the ACLR group had less pain as measured by the P4 ($P = .003$) and KOOS ($P = .007$), with KOOS pain persisting in favor of the ACLR group to 6 months ($P = .02$). No clinically important differences in patient-reported outcome measures were found between groups at other time points. The level of sports activity was similar between groups at 2 years after surgery, as measured by the Marx Activity Rating Scale ($P = .11$).

Conclusion: The addition of LET to a single-bundle hamstring tendon autograft ACLR in young patients at high risk of failure results in a statistically significant, clinically relevant reduction in graft rupture and persistent rotatory laxity at 2 years after surgery.

Registration: NCT02018354 (ClinicalTrials.gov identifier)

Keywords: anterior cruciate ligament reconstruction; lateral extra-articular tenodesis; anterolateral complex; graft failure; young patients

My Paeds ACL Algorithm

COMPLETE ACL Rupture Algorithm

Remaining growth >4years

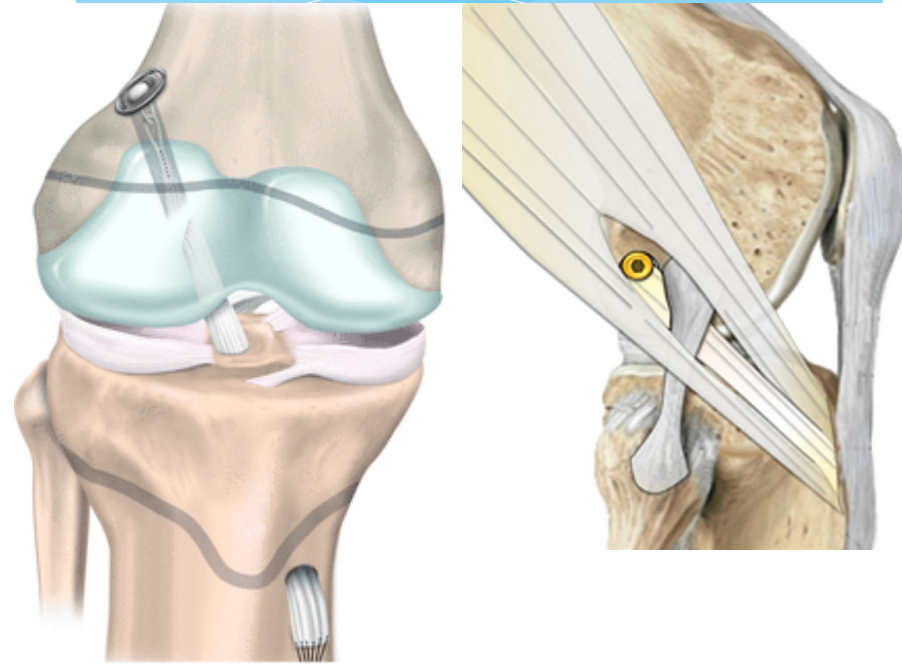
- Parental counselling
- Non-operative trial of brace
- Surveillance (compliance/stability)
- Physeal sparing Iliotibial Band Graft ACLR (Micheli-Kocher Technique)

Remaining growth <4 years

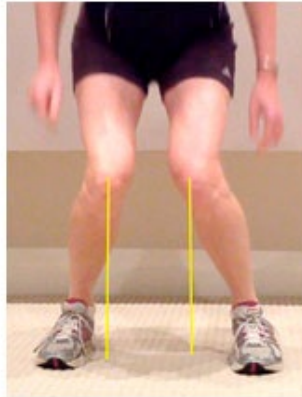
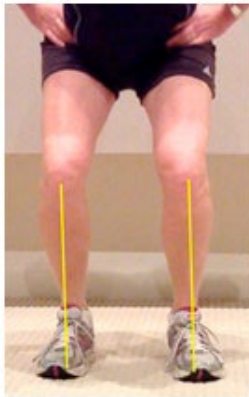
- Transphyseal Hamstring Graft ACLR & Lateral Extra-Articular Tenodesis

Skeletally mature

- Patella Tendon Graft ACLR



Principles of ACL rehabilitation & prevention?



✓ Feet and knees point straight ahead, knee is over toe, feet hip distance apart.

✗ Knees roll inside of feet.

Evidence for ACL injury prevention strategies?

A Randomized Controlled Trial to Prevent Noncontact Anterior Cruciate Ligament Injury in Female Collegiate Soccer Players

Julie Gilchrist,[†] MD, Bert R. Mandelbaum,[‡] MD, Heidi Melancon,[§] MPH, George W. Ryan,[¶] PhD, Holly J. Silvers,[‡] MPT, Letha Y. Griffin,[‡] MD, PhD, Diane S. Watanabe,[‡] MA, ATC, Randall W. Dick,[‡] MS, and Jiri Dvorak,^{**} MD
 From the [†]Division of Unintentional Injury Prevention, National Center for Injury Prevention & Control, Centers for Disease Control & Prevention, Atlanta, Georgia, [‡]Santa Monica Orthopedic & Sports Medicine Research Foundation, Santa Monica, California, the [§]National Recreation and Park Association, Ashburn, Virginia, the [¶]Office of Statistics and Programming, National Center for Injury Prevention & Control, Centers for Disease Control & Prevention, Atlanta, Georgia, ^{**}Peachtree Orthopedics, Atlanta, Georgia, the ^{††}National Collegiate Athletic Association, Indianapolis, Indiana, and the ^{**}Fédération Internationale de Football Association (FIFA), Medical Assessment and Research Center, Schulthess Clinic, Zurich, Switzerland.

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Effectiveness of a Neuromuscular and Proprioceptive Training Program in Preventing Anterior Cruciate Ligament Injuries in Female Athletes

2-Year Follow-up

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TABLE 1
 Prevent Injury and Enhance Performance Program^a

Exercise	Distance	Repetitions/ Time
1. Warm-up		
Jog line to line	50 yd	1
Shuttle run	50 yd	1
Backward running	50 yd	1
2. Stretching		
Calf stretch	NA	2 × 30 s
Quadriceps stretch	NA	2 × 30 s
Hamstring stretch	NA	2 × 30 s
Inner thigh stretch	NA	2 × 30 s
Hip flexor stretch	NA	2 × 30 s
3. Strengthening		
Walking lunges	20 yd	2 passes
Russian hamstring	NA	30 s
Single-toe raises	NA	30, bilaterally
4. Plyometrics		
Lateral hops	2- to 6-in cone	30 s
Forward hops	2- to 6-in cone	30 s
Single-legged hops	2- to 6-in cone	30 s
Vertical jumps	NA	30 s
Scissors jumps	NA	30 s
5. Agilities		
Shuttle run	40 yd	1
Diagonal run	40 yd	1
Bounding run	45-50 yd	1

^aNA, not applicable.

PEP Program – ACL Injury Prevention

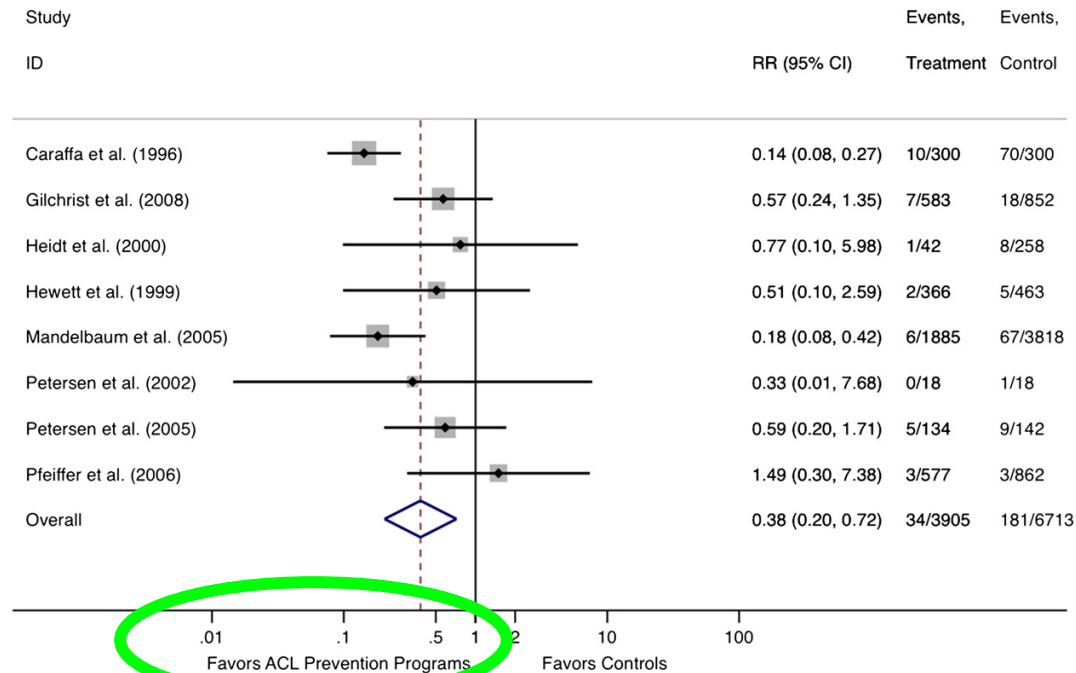


Effectiveness of Anterior Cruciate Ligament Injury Prevention Training Programs

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Pooled Effect of ACL Prevention Program Risk Ratio of ACL Rupture



Evaluation of the effectiveness of neuromuscular training to reduce anterior cruciate ligament injury in female athletes: a critical review of relative risk reduction and numbers-needed-to-treat analyses

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What this paper adds

- ▶ A review of 12 individual studies demonstrated prophylactic effects of neuromuscular training (NMT) by a relative risk reduction (RRR) of 73.4% (95% CI 63% to 81%) for non-contact anterior cruciate ligament (ACL) injury in female athletes.
- ▶ From the needed-to-treat (NNT) analysis, it determined that 108 (95% CI 86 to 150) individuals are necessary to prevent one non-contact ACL injury in female population by NMT intervention.
- ▶ The current study showed NMT reduces overall ACL injury, as demonstrated by an RRR of 43.8% (29% to 56%) in female athletes.
- ▶ The NNT analysis suggested 120 (95% CI 74 to 316) individuals to prevent one overall ACL injury in female athletes by NMT intervention.

ACL Prevention



Key Learning Objectives

- * Why is there an increasing incidence of ACL rupture amongst young people?
- * What is the goal of ACL reconstruction surgery?
- * Why is ACL reconstruction different in younger patients?
- * Non-surgical treatment outcomes
- * Evidence for ACL injury prevention programs





QUESTIONS?