Anterior Cruciate Ligament Injury

Evidence Based "Cheat Sheet"

PREVALENCE

- Common Injury in Physical Active Individuals
- Approximately 250 000 ACL injuries occur per year in the USA (2)
  - Around 50% of those injuries undergo ACL-R (2)
- Incidence of approximately 85 per 100,000 in patients aged between 16 and 39 years (3)
- Every year :
  - Around 3% of recreational athletes injure their ACL
  - Up to 15% of elite athletes

POPULATION

- Greatest in athletes 19-40 years old
  - Non-contact is primary MOI
- Pivoting sports:
  - Soccer, basketball, football, volleyball, handball, gymnastics & skiing
- Females:
  - 2-8x as likely to sustain ACL injury

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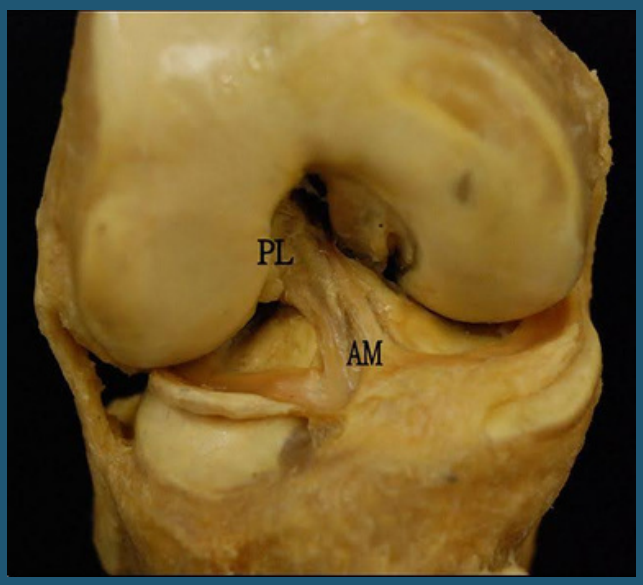
ANATOMY

- Ligament (bone to bone)
- Attaches from femur to tibia
- Blending with the anterior horn of the medial meniscus. (4)
- Anteromedial bundle (AMB) (4)
  - Smaller
  - Lax in knee extension
  - Tightens in knee flexion (5)
  - Primary stabilizer in higher degrees of knee flexion
- Posterolateral bundle (PLB) (4)
  - Larger
  - Tightened (taut) in knee extension (5)
  - Primary stabilizer in knee flexion <30 degrees
  - Rotation / Shear
  - Lax in knee flexion



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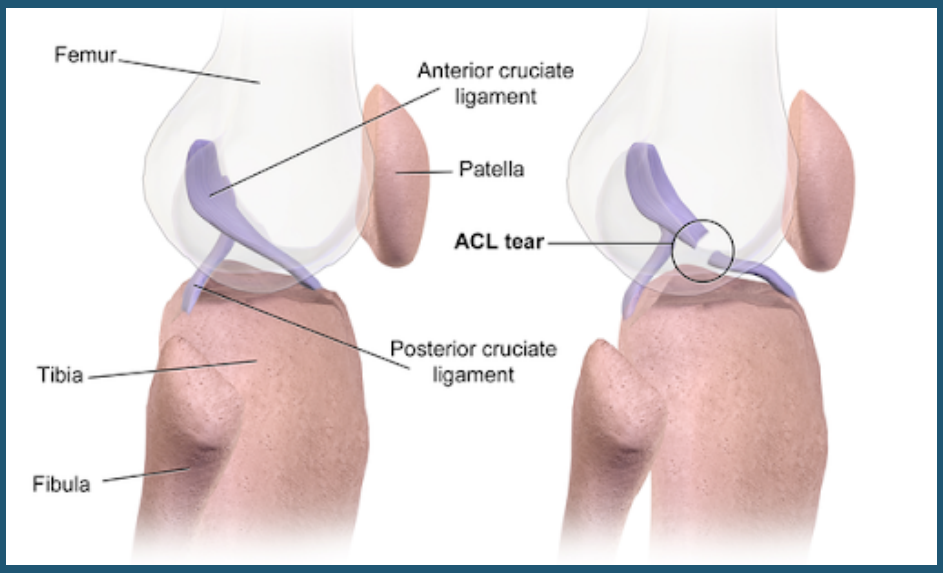

File source: https://upload.wikimedia.org/wikipedia/commons/b/b8/ACL_Tear.png attribution: BruceBlaus, CC BY-SA 4.0 <https://creativecommons.org/licenses/by-sa/4.0>, via Wikimedia Commons Edited by fitness pain free LLC

BIOMECHANICS

Function: (1)

- Anterior Tibial Translation
  - Primary restraint
- Tibial Internal Rotation
  - Particularly in knee extension
- ACL deficient knees present with more tibial anterior translation and rotary instability
- Contains mechanoreceptors
  - Influences the neuromuscular control of the knee

MECHANISM OF INJURY

- 13 studies 542 athletes
- 91% professional
- 71% male
- Soccer (33%) & Football (26%) most common sports
- Non-contact injuries: 42.9%
- DIRECT contact injuries: 22.4%
- INDIRECT contact injuries: 32%
- Most common injury:
  - Planted foot 91.7%
  - Full or near full knee extension 84%
  - Axial loading 81.3%
  - Deceleration/shift in momentum 50.4%,
  - Pivoting maneuver 36.1%,
  - Knee valgus 76.8%,
    - Associated internal 53.5% or external tibiofemoral rotation 57.7%

Review

> Arthroscopy. 2024 Apr 23:S0749-8063(24)00275-5. doi: 10.1016/j.arthro.2024.03.047. Online ahead of print.

Most Anterior Cruciate Ligament Injuries in Professional Athletes Occur Without Contact to the Injured Knee: A Systematic Review of Video Analysis Studies

Varun Gopinatth [1], Matthew V Smith [2], Matthew J Matava [2], Robert H Brophy [2], Derrick M Knapik [2]

Affiliations + expand

PMID: 38663569
DOI: 10.1016/j.arthro.2024.03.047

PREDICPOSING RISK FACTORS (ANATOMIC)

Prior research implicated: (8)

- Females: High body mass, knee hyperextension, and anteroposterior (AP) laxity of the knee, decreased ACL size, narrow intercondylar notch, increased posterior tibial slope, poor tibiofemoral congruity, and increased hip anteversion
- Males: generalized joint hypermobility and knee hyperextension increase ACL injury risk
- Secondary injuries: medial collateral ligament injuries of grade ≥2, lateral meniscus posterior root tears, medial meniscus ramp lesions and anterolateral structure injuries are associated with residual rotatory laxity and have been shown to be risk factors for ACL failure, as well as younger age, increased posterior tibial slope, and knee hyperextension

> Am J Sports Med. 2024 Nov 18:3635465241292755.
doi: 10.1177/03635465241292755. Online ahead of print.

Anatomic Risk Factors for Initial and Secondary Noncontact Anterior Cruciate Ligament Injury: A Prospective Cohort Study in 880 Female Elite Handball and Soccer Players

Yusuke Kamatsuki [1], Marie Synnøve Qvale [1], Kathrin Steffen [1], Arnlaug Wangensteen [1], Tron Krosshaug [1]

Affiliations + expand

PMID: 39555633
DOI: 10.1177/03635465241292755

- 880 non-contact ACL injuries
- Higher powered study than past studies (looking at non-contact)
- Female athletes
  - Static knee valgus was significantly higher in the new injury group
    - Tendency was clearer in the previous ACL injury players
  - Players with secondary injury also had a higher degree of genu recurvatum as compared with previously injured players who did not have a secondary injury

PREDISPOSING INTRINSIC RISK FACTORS

- 145 female Japanese soccer players
- Looking for potential risk factors (non-contact)
- 25 variables: anthropometric data, joint range of motion, muscle flexibility, muscle strength, and balance measurements.
- Monitored throughout a single season for noncontact ACL injuries (13 total injuries)
- Risk Factors Associated with ACL Injury:
  - Lower hamstring-to-quadriceps ratio
  - Greater knee extension muscle strength
  - Longer soccer experience

> Am J Sports Med. 2024 Oct;52(12):2972-2979.
doi: 10.1177/03635465241278745. Epub 2024 Sep 25.

Intrinsic Risk Factors for Noncontact Anterior Cruciate Ligament Injury in Young Female Soccer Players: A Prospective Cohort Study

Shuji Taketomi [1 2], Kohei Kawaguchi [3 4 2], Yuri Mizutani [5 2], Seira Takei [5 2], Ryota Yamagami [1 2], Kenichi Kono [1 2], Ryo Murakami [1 2], Takahiro Arakawa [1 2], Tomofumi Kage [1 2], Takashi Kobayashi [1 2], Yuri Furukawa [1 2], Yusuke Arino [6 2], Sayaka Fujiwara [7 2], Sakae Tanaka [1 2], Toru Ogata [7 2]

Affiliations + expand

PMID: 39320411
DOI: 10.1177/03635465241278745

PREDISPOSING EXTRINSIC RISK FACTORS

> Sports Med. 2024 Apr;54(4):875-894.
doi: 10.1007/s40279-023-01975-1. Epub 2024 Jan 18.

Extrinsic Risk Factors for Primary Noncontact Anterior Cruciate Ligament Injury in Adolescents Aged between 14 and 18 years: A Systematic Review

Matteo Crotti [1], Theresa Heering [2 3], Natalie Lander [4], Aaron Fox [5], Lisa M Barnett [3 4], Michael J Duncan [2]

Affiliations + expand

PMID: 38236505
DOI: 10.1007/s40279-023-01975-1

- Examining prior risk factors linked to primary ACL injury
- 16 total studies
  - Specific sport (8 studies); sport exposure amount (5 studies); sport level (3 studies); sport season (1 study); environment (2 studies); equipment (1 study)
- Contrasting evidence about associations between sport exposure and biomechanical / neuromuscular risk factors
  - Weak evidence of differences in biomechanical risk factors
- Higher sport level may be associated with increased injury risk

SPORT, SEX, LEVEL OF COMPETITION

- College athletes higher injury risk over high school athletes (10)
- Females >2x as likely to be injured as males (10)
- Relative risk greater in basketball and soccer
- Females: Soccer > Basketball > Lacrosse
- Males: Football > Lacrosse > Soccer
- 6-8x more likely to occur during match vs. practice (12)

Review > Am J Sports Med. 2016 Oct;44(10):2716-2723.
doi: 10.1177/0363546515617742. Epub 2015 Dec 11.

Sport-Specific Yearly Risk and Incidence of Anterior Cruciate Ligament Tears in High School Athletes: A Systematic Review and Meta-analysis

Alex L Gornitzky [1], Ariana Lott [1], Joseph L Yellin [1], Peter D Fabricant [1], J Todd Lawrence [1], Theodore J Ganley [2]

Affiliations + expand

PMID: 26657853
DOI: 10.1177/0363546515617742

Original research

Healing of acute anterior cruciate ligament rupture on MRI and outcomes following non-surgical management with the Cross Bracing Protocol

PDF

PDF + Supplementary Material

Stephanie R Filbay [1], Matthew Dowsett [2], Mohammad Chaker Jomaa [3], Jane Rooney [4], Rohan Sabharwal [5], Phil Lucas [5], Andrew Van Den Heever [5], James Kazaglis [6], Justin Merlino [6], Mick Moran [6], Maggie Allwright [7], Donald E K Kuah [8], Ra Durie [9], Greg Roger [10, 11], Mervyn Cross [12], Tom Cross [12]

Correspondence to Dr Stephanie R Filbay, Department of Physiotherapy, The University of Melbourne, Melbourne, VIC 3010, Australia; stephanie.filbay@unimelb.edu.au

DO ACL TEARS HEAL?

Common Wisdom: ACL tears generally do NOT heal well due to limited blood supply

- 30% of complete ACL tears randomized to initial rehab will show "ligament continuity" [MRI] at the 2 year mark (KANON trial)
  - *Copers?*
- Cross-bracing: 90% (72 of 80) of complete ACL tears showed MRI "continuity" at 3 month mark
  - More healing on MRI correlated with better self-reported knee function and knee-related quality of life, higher return to sport rates and reduced knee laxity

Cross-bracing:

- 4-weeks after injury
- Braced @90 degrees (shortens the ACL)
- Slow incremental increase in extension after 4 weeks
  - 10 weeks unrestricted ROM
  - 12 weeks completely get rid of brace
- Physical Therapy
  - Lower limb neuromuscular control, muscle strengthening and power, and functional training to enable return-to-sport and recreational activities

Cross-bracing:

- 14% ACL re-injury rate (5-18 months after)
- 2 DVTS (2 of 80)
- Ligament continuity correlated with better ACL OA Score (MRI Injury Scoring System):
  - RTS (92% vs 64%)
  - Normal knee laxity (100% vs. 40%)
  - Knee function and QOL

Keep in mind:

- You may not need an intact ACL to successfully rehabilitate...

SURGERY

Defined as:

- Reconstruction of the torn ACL (ACL-R)
  - Autograft
    - Patellar
    - Hamstring
    - Quadriceps
  - Allograft
    - Cadaver
  - Majority of comparison studies
- Repair
- Bridge Enhanced ACL Repair (BEAR)

ACL INJURY TYPES & TREATMENTS

- Grade 1: Generally conservative
  - Degree of instability reflects outcomes
- Grade 2: Generally conservative
  - Partial tears > Full tears (conservatively)
- Grade 3: Generally surgical

Cureus
Publishing Beyond Open Access

Cureus. 2024 Mar 20;16(3):e56532. doi: 10.7759/cureus.56532

Conservative vs Surgical Treatment of Anterior Cruciate Ligament Rupture: A Systematic Review

Andreas Papaleontiou [1,✉], Andréa M Poupard [2], Uday D Mahajan [1], Panteleimon Tsantanis [1]

Editors: Alexander Muacevic, John R Adler

"Current literature does not conclude whether operating on patients with an ACL injury is more beneficial than not operating. In addition, there is no clear consensus on whether surgery benefits certain patient groups more than others. Clear evidence-based guidance must be introduced to avoid unnecessary surgeries."

"This literature review evaluates whether surgical management of ACL injury is superior to non-surgical treatment."

- 5 papers
- 462 patients
  - >15 years old
  - ACL Tear (complete)
  - ACL-R or Conservative
    - Autografts and Allografts
    - PT, education about instability reduction
- Outcome measures
  - Overall knee health, joint stability and function, development of osteoarthritis, and patient activity level

- Tsoukas 2016 & Kessley 2008:
  - Surgery = higher IKDC score
- Sandberg 1987
  - No difference Tegner and Lysholm
  - Conservative pts reported “giving way” vs. none in surgical
- Frobell 2010, 2013:
  - No difference in KOOS (pain, symptoms, function, QOL, sports)
- Knee Stability (Frobel)
  - Conservative group, 33% normal Lachman & 40% normal pivot shift.
  - Operated group, 76% normal Lachman test & 76% normal pivot shift.

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Laxity Testing: KT-1000
“Significant increase in laxity in the conservative groups overall”
Physical Activity: (Tsoukas, Sandberg, Kessler)

- Non-operated patients' satisfaction with their ability to participate in physical activities decreased more with time than the operated group

Osteoarthritis: Strong correlation between ACL injury & osteoarthritis

- Nebelung et al. increased risk of high-level athletes with definitive unstable knee developing cartilage lesions over 20 years
- Sherman et al. Neyret et al. reported that chronic knee instability leads to cartilage degeneration. Newman et al. found osteoarthritis in 51% of men and 41% of women with ACL injury after 12-14 years
-

“Despite the evidence supporting the importance of an intact ACL in decreasing the risk of cartilage degeneration, the literature does not prove that reconstruction reduces the risk”

RETURN TO SPORT

> Am J Sports Med. 2022 Mar;50(4):912-921.
doi: 10.1177/03635465211073152. Epub 2022 Feb 11.

Long-term Return to Sports After Anterior Cruciate Ligament Injury: Reconstruction vs No Reconstruction-A Comparison of 2 Case Series

Susan L Keays [1] [2], Daniel B Mellifont [1], Anthony C Keays [2], Max C Stuelcken [1], Dale I Lovell [1], Mark G L Sayers [1]

Affiliations + expand

PMID: 35148249
DOI: 10.1177/03635465211073152

History:
- RTS rates after ACL reconstruction are generally poor (<50% in some studies)
- ACL-R vs. Non-operative management are similar… (1 year mark)

This study:
- 101 patients ACL deficiency
  - 56 ACL-R (9 year follow-up)
  - 45 non-op (11 year follow-up)
- Are long-term follow-up results same as short-term? (1 year)

RTS Rates: Reconstruction vs. NON-reconstructed
- 96% vs. 93% continued to play sports
- 4% and 7% did NOT RTS
- 8% and 17% returned to safe sports
- 13% and 12% returned to running
- 20% and 26% returned to sports involving limited twisting
- 12% and 24% returned to recreational pivoting sports
- 43% and 14% returned to competitive pivoting sports.
- The only significant difference was in return to competitive pivoting sports
  - *3x the rate of non-surgical management*

ACL TEAR & MENISCUS INJURY

Original research

PDF

Meniscal procedures are not increased with delayed ACL reconstruction and rehabilitation: results from a randomised controlled trial FREE

Sabine J A van der Graaff [1], Max Reijman [1], Eline M van Es [1], Sita M A Bierma-Zeinstra [2], Jan A N Verhaar [1], Duncan E Meuffels [1]

Correspondence to Dr Duncan E Meuffels, Orthopaedics and Sports Medicine, Erasmus Medical Center, Rotterdam, 3015 GD, The Netherlands; d.meuffels@erasmusmc.nl

Details:
- Delayed ACL-R vs. Immediate ACL-R (2023)(9)
- Meniscus injuries between groups

Results:
- No difference in meniscus pathology over 2-year follow-up period

Conclusion:
- ACL-R can be delayed without increased risk of meniscus pathology

Limitations:
- Do patients reduce activity from injury?
  - Activity levels following injury not reported in this study or prior studies showing increased meniscus injury risk
  - Lower activity level may reduce injury risk

SHOULD YOUR PATIENT HAVE SURGERY?

Currently, both operative and non-operative management are acceptable methods for treating ACL injuries
Factors favoring Surgery

- Return to pivoting sports
- Non-copers (can't return to sport OR activities)
- Patients with subjective and objective laxity (KT-1000)
- Concomitant injury: Repairable meniscus
- Age?
  - Advanced age used to be an indication for non-op management
  - No longer the case...

Review > J Clin Med. 2024 Oct 18;13(20):6233.
doi: 10.3390/jcm13206233.

Anterior Cruciate Ligament Tear: Individualized Indications for Non-Operative Management

George A Komnos [1], Michael H Hantes [2], Georgios Kalifis [3], Nifon K Gkekas [1], Artemis Hante [4], Jacques Menetrey [5]

Affiliations + expand

PMID: 39458183
PMCID: PMC11508887
DOI: 10.3390/jcm13206233

ACL-RECONSTRUCTION SURGERY

RECONSTRUCTION of the native ACL after a complete tear
Utilizes a graft (Auto or Allo) to make a new ACL (NOT repaired)
Goal:

- Replicate native ACL
- Restore anterior / posterior stability
- Restore rotary stability
- Match qualities of ACL
  - Length, CSA, stiffness, tissue make-up etc...

Graft Choices:

- Autograft
  - Hamstring tendon (most common worldwide)
  - Patellar tendon (bone patellar tendon bone [BPTB])
    - Historically "gold standard"
  - Quadriceps tendon
    - Most closely resembled size of native ACL footprint
- Allograft
  - Cadaver graft
    - All soft tissue
      - Hamstring, tib. ant. & post., peroneal, IT band
    - Bone tendon
      - BPTB, bquad, b(calcaneus)achilles

JEO Journal of Experimental Orthopaedics
THE OFFICIAL OPEN ACCESS JOURNAL OF ESSKA

J Exp Orthop. 2023 Apr 1;10:37. doi: 10.1186/s40634-023-00600-4

Current trends in graft choice for anterior cruciate ligament reconstruction – part I: anatomy, biomechanics, graft incorporation and fixation

Armin Runer [1,2,✉], Laura Keeling [1], Nyaluma Wagala [1], Hans Nugraha [3], Emre Anil Özbek [1,4], Jonathan D Hughes [1,5], Volker Musahl [1,5]

Author information Article notes

PMCID: PMC10067784 PMID: 37005974

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Affiliations + expand

PMID: 35148249
DOI: 10.1177/03635465211073152

Graft Incorporation: "Ligamentization"

- Process where graft takes on new characteristics to match prior ACL
  - 6 months to 4 years (5)
- 6 months to years overall...
  - BPTB 6-12 months
  - Hamstring 12-24 months
  - Quad faster than hamstring
  - Allograft - Slower graft maturation process overall
  - Mixed evidence - Doesn't correlate with laxity clinically

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Author information · Article notes
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PMCID: PMC10067784 PMID: 37005974

Patient Reported Outcome Measures

- Quad tendon vs. BPTB vs. Hamstring
  - No difference in outcomes generally
  - Lower morbidity in QT
  - Double bundle hamstring improves functionality & complication rate vs. single (8)
    - 2 grafts (Semitendinosus & Gracilis)
- Autograft vs. Allograft
  - Older research reported worse outcomes in allograft
  - Newer research shows no difference

Graft Failure Rates

- QT and BPTB similar failure rate (2)
  - [1.4-7.5%] vs. [2.0-5.1%]
- HS rate higher
  - 2.8 BPTB vs. 2.84 HS (47,613 patients)(3)
  - Up to 2x more common in some studies (2)
  - Pronounced in younger athletic patients (2)
- Allograft vs. Autograft
  - Higher rupture and reoperation rates
  - Up to 6x more likely to re-tear
    - Particularly in young athletic patients
  - Substantially LOWER retear rates in older and less athletic patients
    - No difference between different types of allograft (achilles, tib ant / post. etc) (6)
- Bioabsorbable screws (vs. metal screws) reduce failure rates (8)

Strength:

- Knee extensor strength (2,4)
  - HS > BPTB > QT (5-8 months)
    - May normalize between 9-15 months (2)
- Knee flexor strength (2)
  - HS reduced substantially up to 2 years following surgery
  - QT = BPTB

Return to Sport

- 82% Overall RTS
- 63% RTS at same level
- Generally no difference between graft types
  - QT potentially better but mixed evidence
  - Similar RTS rates for allograft also...
    - Autograft potentially better

Donor Site Morbidity / Complications

- BPTB > Anterior knee and kneeling pain vs. HS graft vs. QT graft
  - 72% vs. 44% vs. 9.3%
  - QT soft tissue graft significantly more pain then QTPT (2.7x) (9)
    - 23% vs. 9%
- HST higher risk of infection (5-8x BPTB)
  - QT least risk
- Allograft higher risk of infection vs. autograft
- Allograft - no donor site morbidity...
  - Shorter surgery times

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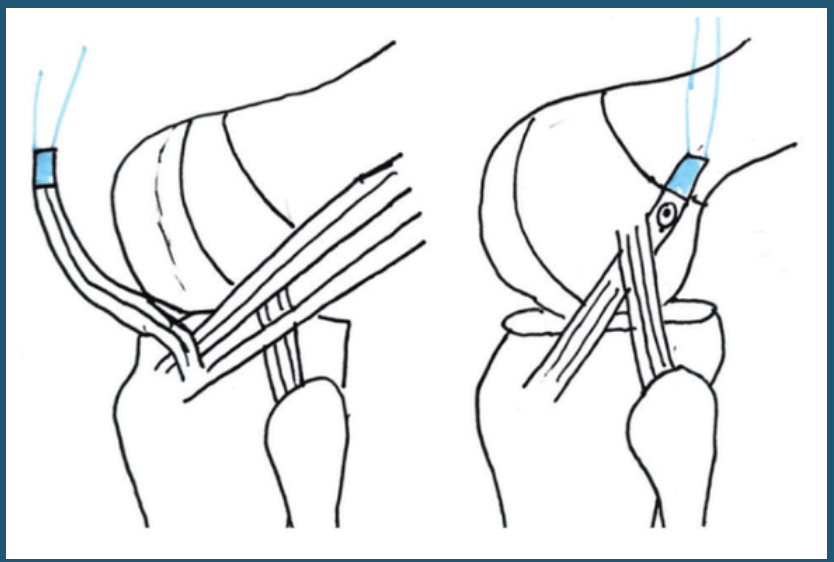
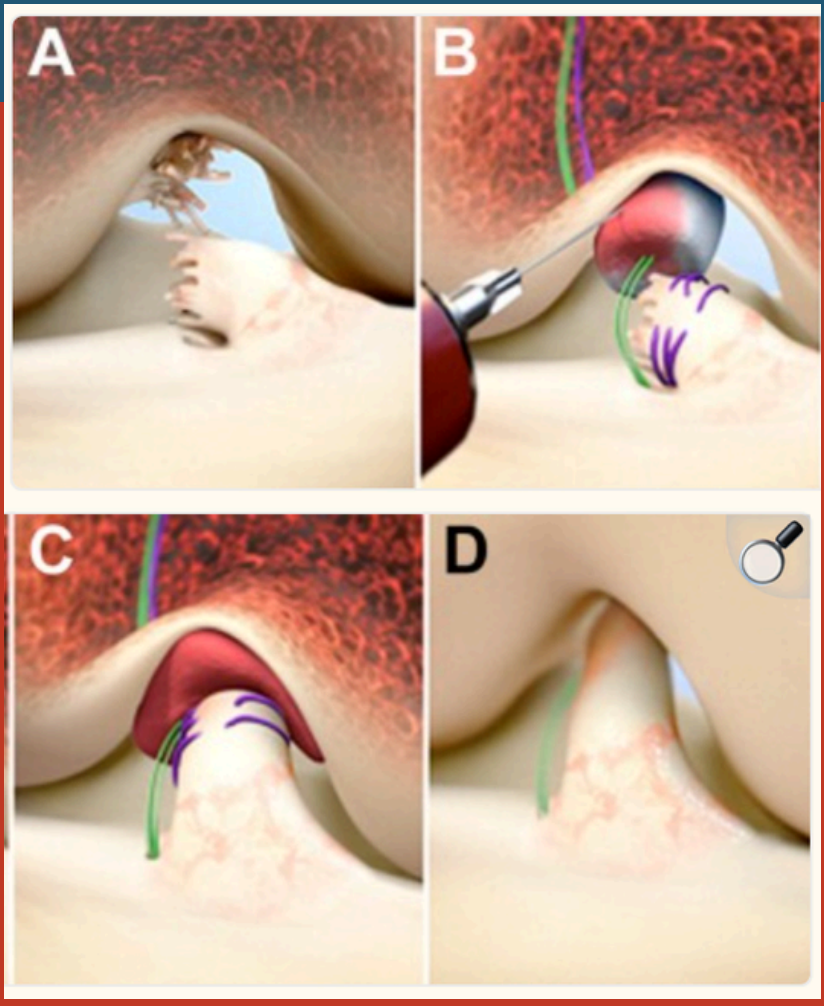


LATERAL EXTRA-ARTICULAR TENODESIS

- Detach a part of the IT band proximally:
- Transfer it under the LCL + fix to femur
- Performed in conjunction with ACL-R
- Improves rotational stability
- Improves RTS rates (11)
  - 100% RTS rate Green et al. 2023
  - Quad tendon
- Decreased re-tear rates
  - 11% to 4% (HS + LET)

Table 1. The indications for adding an LET to ACLR are generally those that increase the risk of graft failure

Relative Indications for LET
Female Population
Soccer Athletes
Elite Athletes (national or international level)
Inherent ligamentous laxity
Increased posterior tibial slope
High grade pivot shift
Revision ACL surgery
Meniscal root tears and subtotal meniscectomies
Chronic ACL tear



BRIDGE ENHANCED ACL REPAIR (BEAR)

- Tunnels drills through tibia and femur
- Suture repair (mid-substance tear)
- Bioactive scaffold to the repair site (10 mL of whole blood) (16)
  - Extracellular matrix proteins, including collagen, that were obtained from bovine tissue
- ACL heals over time: Pigs treated with BEAR had less OA over time vs. ACL-R (16)

BEAR vs. ACL-R Outcomes (15)

- 2 studies (meta-analysis 2023)
  - Autograft (Hamstring & BPTB)
    - 100 participants
      - 65 BEAR, 35 ACL-R
  - Autograft (Hamstring)
    - 20 participants
      - 10 BEAR, 10 ACL-R

Outcomes:

- Strength: hamstring, quadriceps, and hip abduction
  - BEAR outperformed ACL-R hamstrings only
- Hop tests
- BEAR better 6m distance hop
- Rest results same
- RTS clearance:
  - By 1 year, an estimated 88% of the BEAR group and 76% of the ACLR group had been cleared to return to sports.
    - Similar at 2 years (most likely explained by HS weakness)
  - No mention on % who RTS and RTS at same level...

edp open SICOT-J
ABOUT THE JOURNAL AUTHOR INFORMATION SUBMIT YOUR PAPER THIS ARTICLE

SICOT J. 2023 Apr 13;9:8. doi: 10.1051/sicotj/2023007

Bridge enhanced ACL repair vs. ACL reconstruction for ACL tears: A systematic review and meta-analysis of comparative studies

Jad Mansour [1,*], Joe Ghanimeh [2], Ali Ghoul [3], Michel Estephan [1], Alfred Khoury [2], Mohammad Daher [3]

Author information Article notes

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PMCID: PMC10092275 PMID: 37042698

Outcomes:

- IKDC score & KOOS:
  - BEAR better short term
  - Similar long term
- Failure rates
  - No difference b/t groups
- Anteroposterior (AP) knee laxity
  - No difference in laxity at all time points

WANT TO LEARN MORE ABOUT HOW TO GET YOUR PATIENTS OUT OF PAIN AND BACK IN THE GYM WHERE THEY BELONG?

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CHECK OUT ADDITIONAL ARTICLES AND COURSES DEVELOPED BY DAN AT WWW.FITNESSPAINFREE.COM

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