Challenging Cases: ACL Tear in a College Athlete

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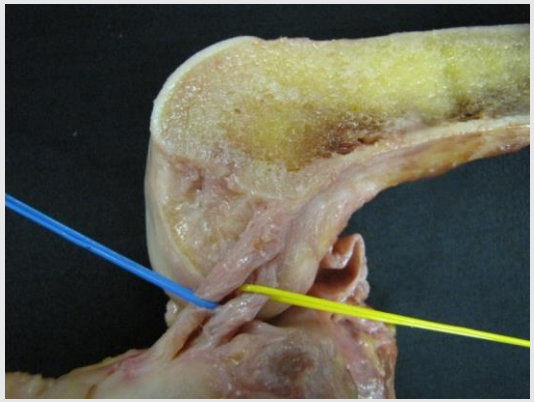
University Orthopaedic Associates

June 1, 2023



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Disclosures

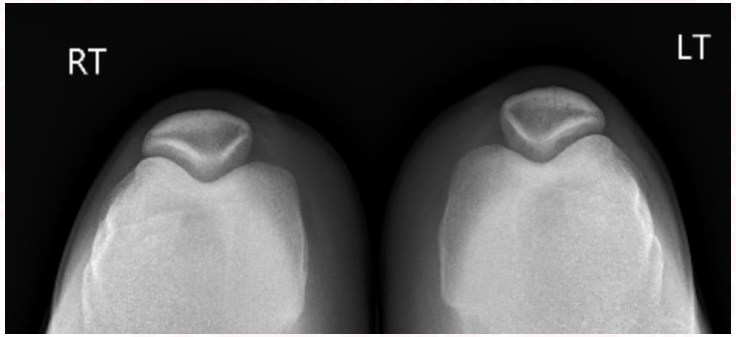
- Smith and Nephew: educational support

- I like data and I don't typically chase shiny objects…

Case Presentation

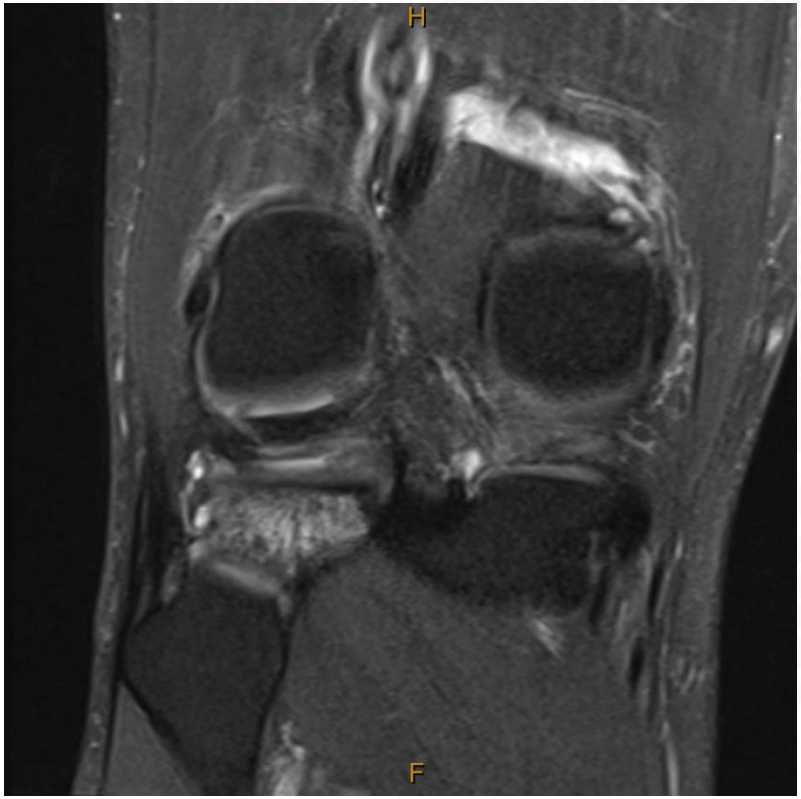
- HPI
  - 23M, 5th year D1 wrestler
  - Recent valgus injury to R knee, felt a pop, 11/2022
  - Able to run but with persistent R knee instability while wrestling
  - Tried to rehab this for 2 months with persistent symptoms
- PMH/PSH
  - L recurrent anterior shoulder instability
- Exam
  - No limp
  - Full ROM, no effusion
  - Grade 2B Lachman, stable posterior drawer
  - No varus/valgus instability at 0 or 30 degrees of flexion

Case Presentation



RUTGERS

Case Presentation



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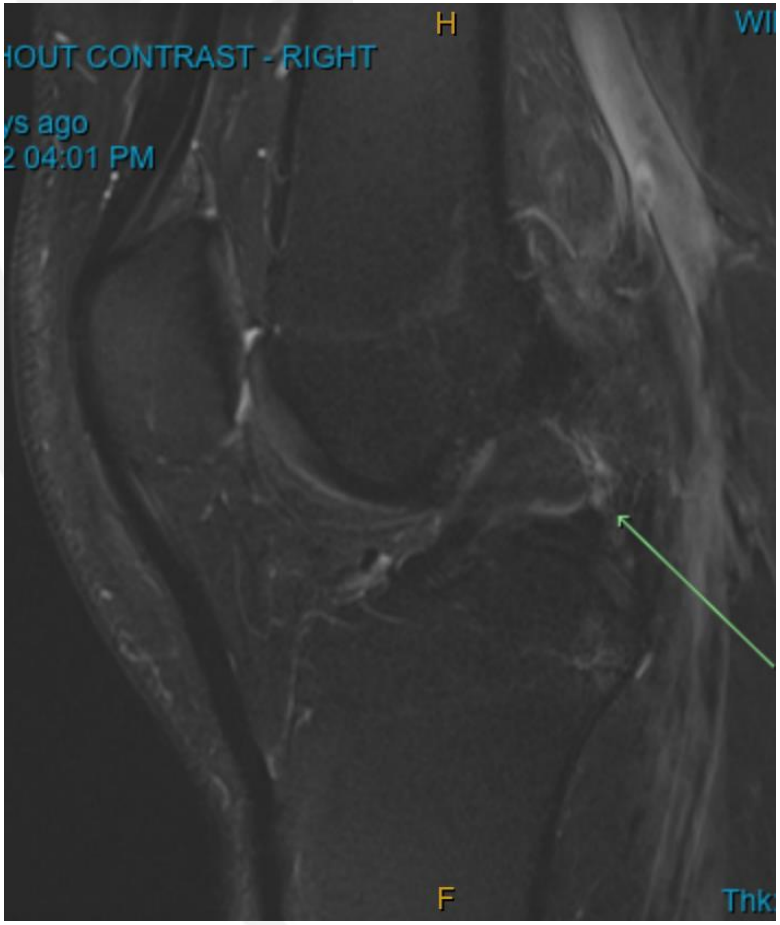

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Treatment Options?

- Non-operative management?

yahoo!sports

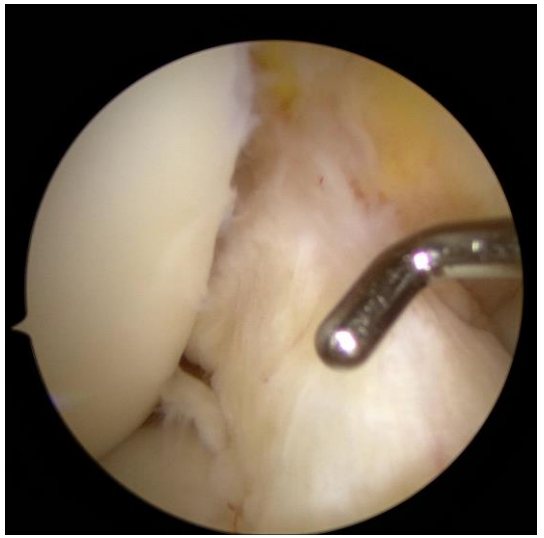
Iowa wrestler Spencer Lee wins national title on torn ACL: 'Excuses are for wusses'

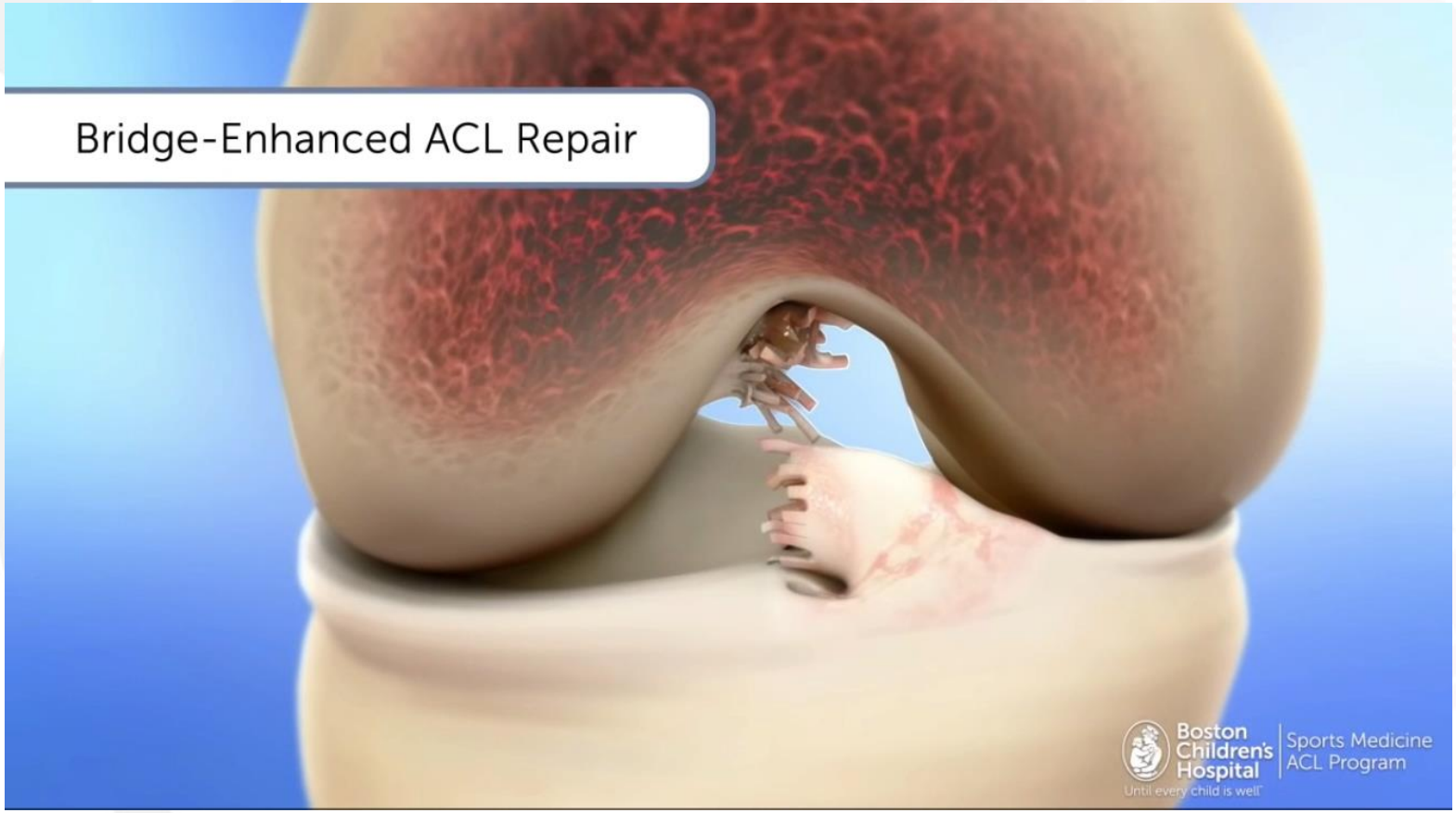
Ryan Young · Staff writer

March 21, 2021 · 2 min read

Treatment Options?

- Non-operative management?
- ACL Reconstruction?
  - Graft choice options
- ACL Repair with internal brace
- ACL BEAR Procedure?




Bridge-Enhanced ACL Repair
Boston Children's Hospital
Until every child is well
Sports Medicine ACL Program

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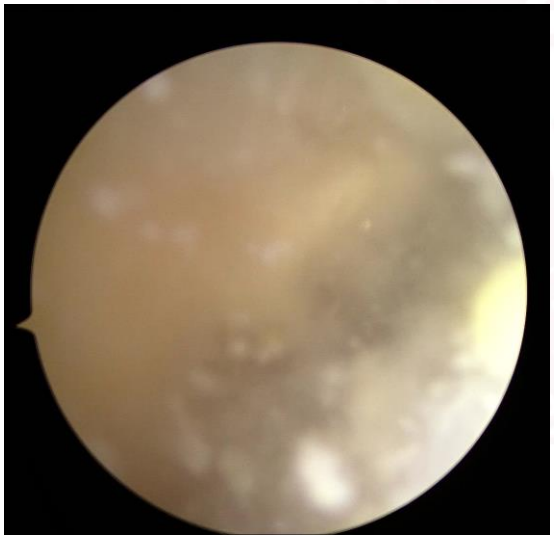
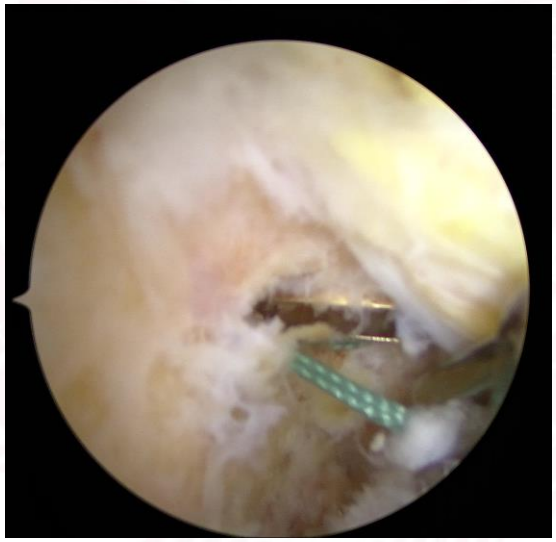
BEAR ACL Repair





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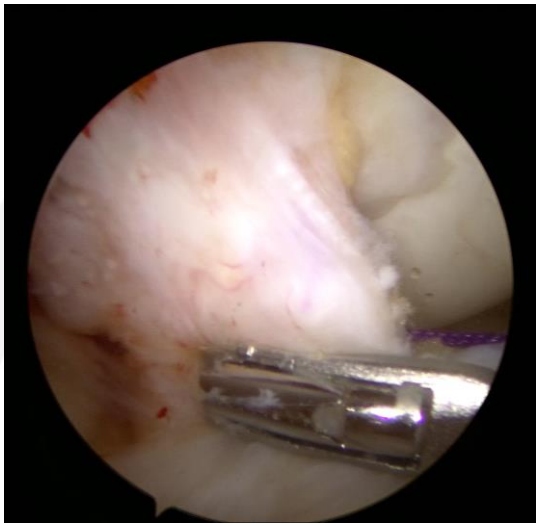
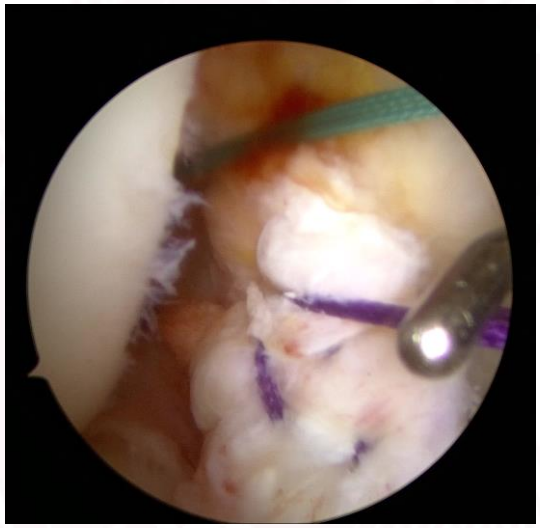
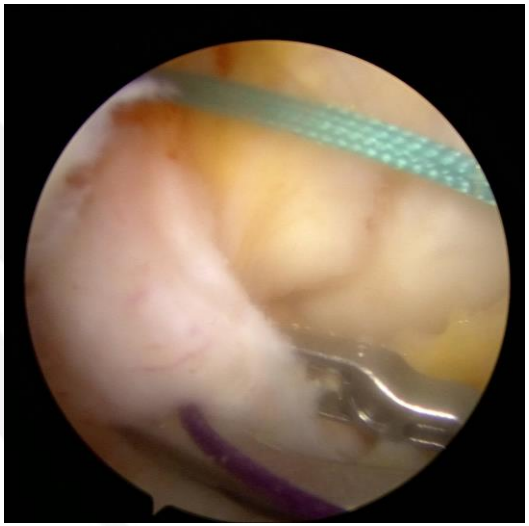
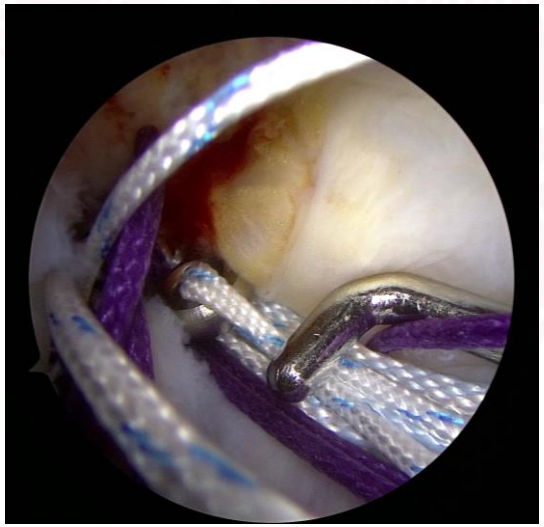
BEAR ACL Repair









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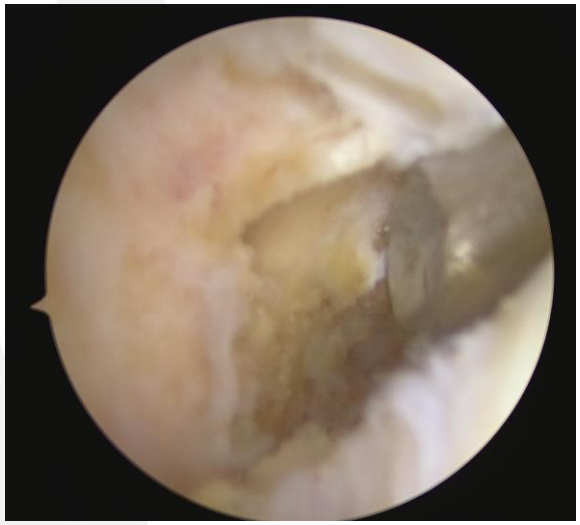
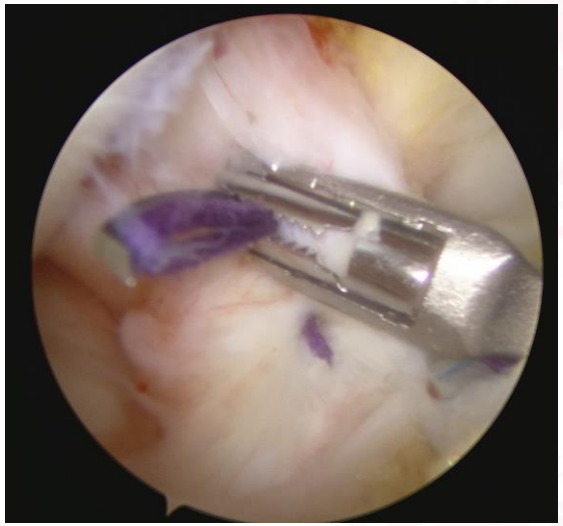
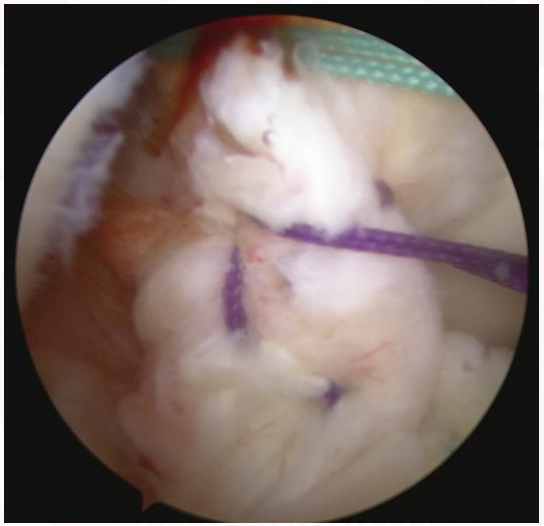
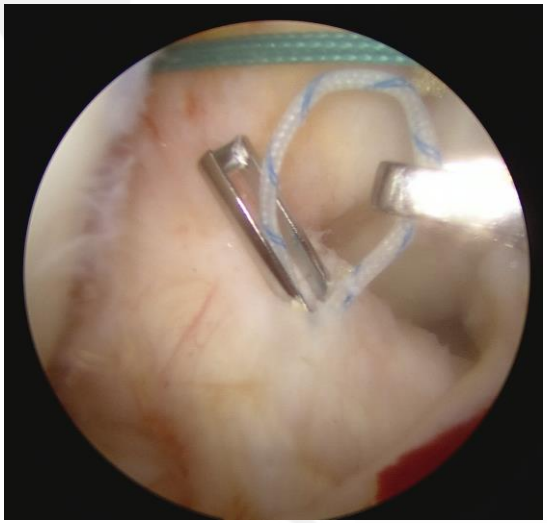
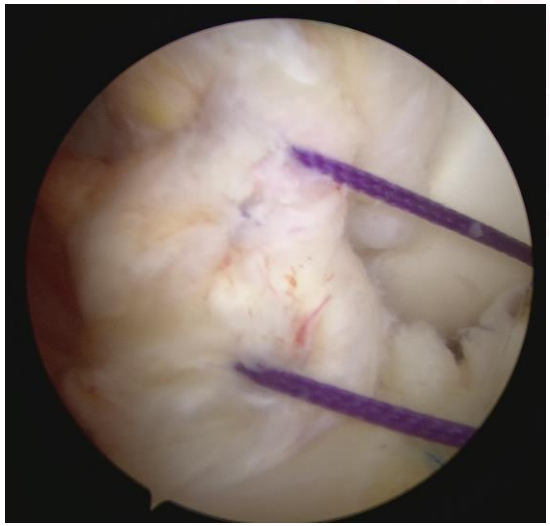
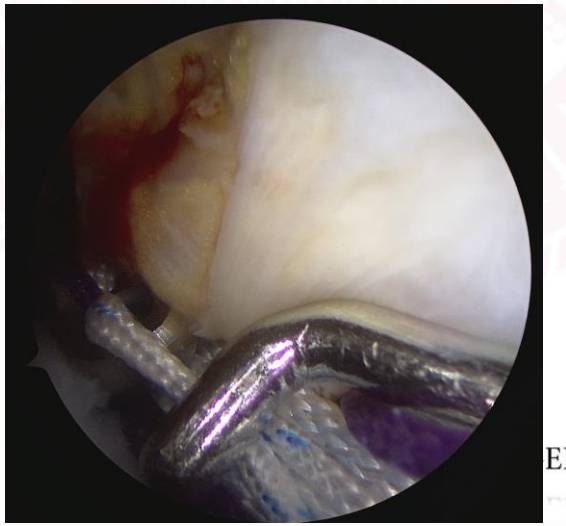

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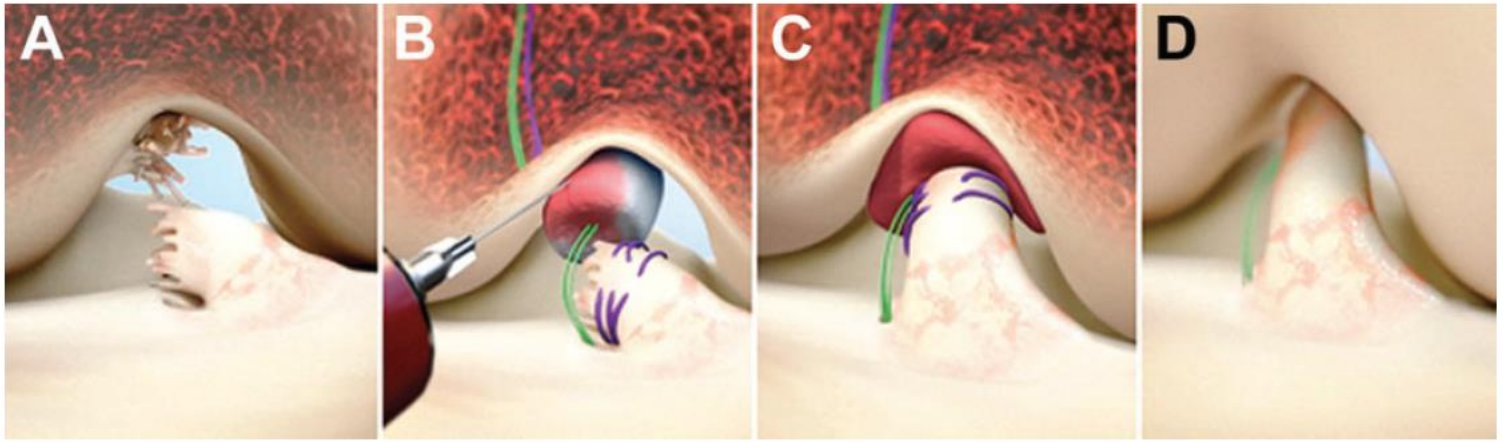
Show me the data!



2 YEAR BEAR II TRIAL DATA

- 100 patients → 65 BEAR, 35 ACLR, 2016-2017
- Inclusion Criteria
  - Complete ACL tear, <45 days after injury, closed physes, >50% ACL length attached to tibia
- Exclusion Criteria
  - Hx of ipsilateral knee surgery, previous knee infection, risk factors for poor wound healing, displaced bucket handle meniscus tear requiring repair (other meniscal injuries included), full thickness chondral injury, grade III MCL tear, concurrent patellar dislocation, PLC injury requiring treatment
- Same post-op protocol

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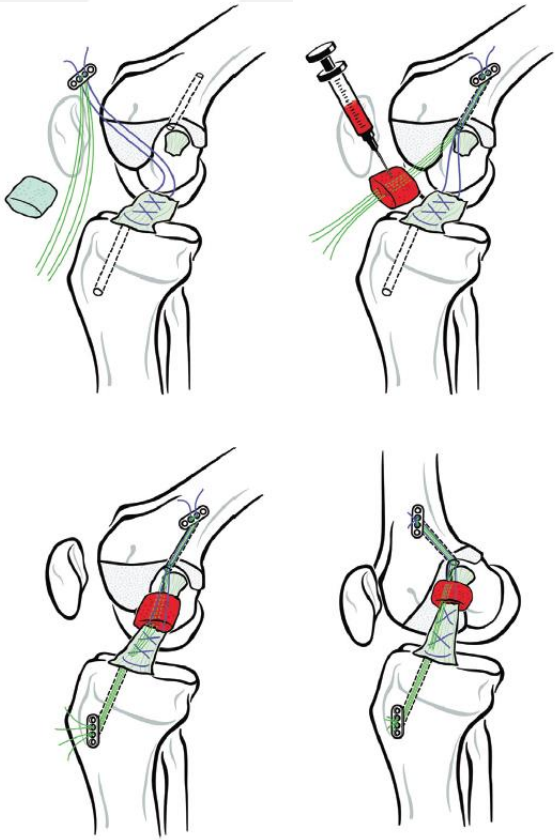

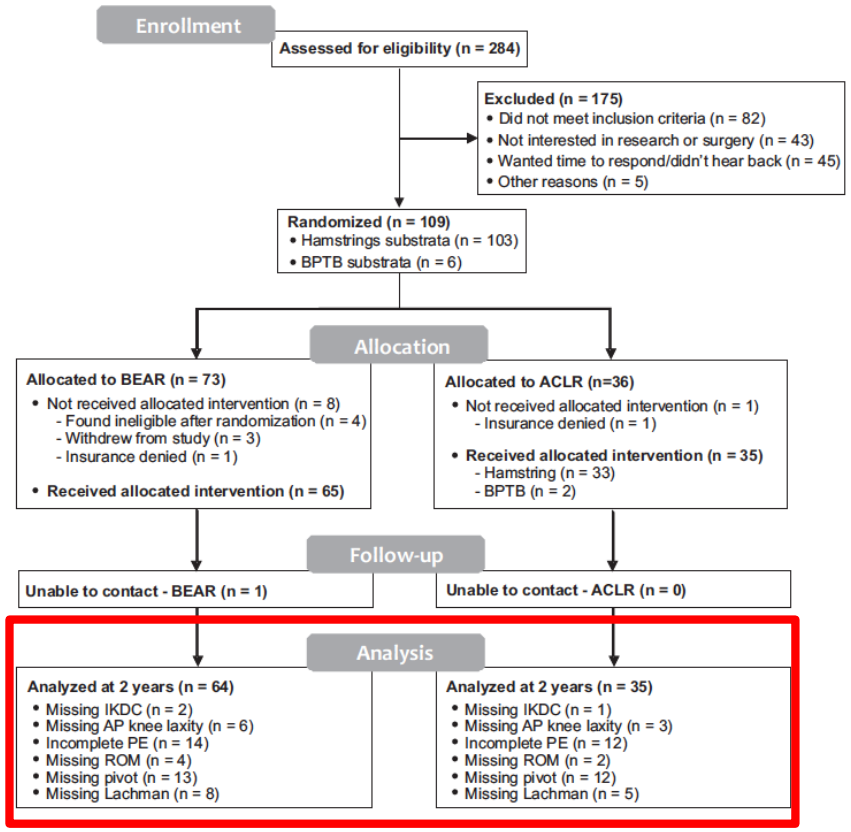
Enrollment
Assessed for eligibility (n = 284)
Excluded (n = 175)
• Did not meet inclusion criteria (n = 82)
• Not interested in research or surgery (n = 43)
• Wanted time to respond/didn't hear back (n = 45)
• Other reasons (n = 5)
Randomized (n = 109)
• Hamstrings substrata (n = 103)
• BPTB substrata (n = 6)
Allocation
Allocated to BEAR (n = 73)
• Not received allocated intervention (n = 8)
- Found ineligible after randomization (n = 4)
- Withdrew from study (n = 3)
- Insurance denied (n = 1)
• Received allocated intervention (n = 65)
Allocated to ACLR (n=36)
• Not received allocated intervention (n = 1)
- Insurance denied (n = 1)
• Received allocated intervention (n = 35)
- Hamstring (n = 33)
- BPTB (n = 2)
Follow-up
Unable to contact - BEAR (n = 1)
Unable to contact - ACLR (n = 0)
Analysis
Analyzed at 2 years (n = 64)
• Missing IKDC (n = 2)
• Missing AP knee laxity (n = 6)
• Incomplete PE (n = 14)
• Missing ROM (n = 4)
• Missing pivot (n = 13)
• Missing Lachman (n = 8)
Analyzed at 2 years (n = 35)
• Missing IKDC (n = 1)
• Missing AP knee laxity (n = 3)
• Incomplete PE (n = 12)
• Missing ROM (n = 2)
• Missing pivot (n = 12)
• Missing Lachman (n = 5)

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TABLE 1
Baseline Characteristics of the 2 Groups[a]

	BEAR (n = 65)	ACLR (n = 35)	*P* Value
Demographics			
Female	37 (57)	19 (54)	.84
White, non-Hispanic[b]	55 (86)	26 (74)	.18
Age, y	17 (16-20)	17 (15-23)	.76
Body mass index	24.7 ± 3.8	23.3 ± 4.5	.11
Noncontact injury	48 (74)	29 (83)	.46
Injury to surgery, d	36 (29-42)	39 (33-43)	.15
Baseline score			
IKDC[b]	50.0 ± 16.7	45.5 ± 14.6	.18
Marx[c]	16 (13-16)	16 (13-16)	.62
MRI findings			
Torn PCL	0 (0)	0 (0)	≥.99
Torn MCL	0 (0)	1 (3)	.35
Torn LCL	0 (0)	0 (0)	≥.99

[a]Data are presented as No. (%), median (interquartile range), and mean ± SD. ACLR, anterior cruciate ligament reconstruction; BEAR, bridge-enhanced anterior cruciate ligament repair; IKDC, International Knee Documentation Committee; LCL, lateral collateral ligament; MCL, medial collateral ligament; MRI, magnetic resonance imaging; PCL, posterior cruciate ligament.
[b]BEAR, n = 64; ACLR, n = 35.
[c]BEAR, n = 64; ACLR, n = 34.

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TABLE 2
Intraoperative Findings and Additional Procedures[a]

	BEAR (n = 65)	ACLR (n = 35)	*P* Value
Length of ACL tibial remnant, %			.38
<50	0 (0)	0 (0)	
50-74	57 (88)	28 (80)	
75-100	8 (12)	7 (20)	
≥1 meniscal tears			
Medial	5 (8)	6 (17)	.19
Lateral	26 (40)	20 (57)	.14
Treatment of meniscal tears[b]			.48
Repair	15 (56)	15 (68)	
Abrasion/trephination	2 (7)	1 (5)	
Excision	6 (22)	3 (14)	
No surgical treatment	4 (15)	3 (14)	
Effusion grade[c]			.12
None	17 (26)	15 (44)	
Mild	38 (58)	15 (44)	
Moderate	10 (15)	4 (12)	
Severe	0 (0)	0 (0)	
Firm Lachman endpoint[c]	1 (2)	1 (3)	≥.99
Pivot shift			.67
Negative	0 (0)	1 (3)	
Glide	13 (20)	5 (14)	
Clunk	41 (63)	25 (71)	
Gross	11 (17)	4 (11)	

[a]Data are presented as No. (%). ACL, anterior cruciate ligament; ACLR, ACL reconstruction; BEAR, bridge-enhanced ACL repair.
[b]If patients had >1 treatment, they were categorized as the first type listed. For example, if patients had both repair and excision, they were categorized as repair. Analysis of meniscal treatment is restricted to patients with ≥1 meniscal tears (BEAR, n = 27; ACLR, n = 22).
[c]BEAR, n = 65; ACLR, n = 34.

TABLE 3
Primary Outcomes at 2 Years: IKDC Subjective Score and AP Knee Laxity[a]

	BEAR		ACLR			*P* Value	
	No.	Mean (SD)	No.	Mean (SD)	Mean Difference (95% CI)[b]	Noninferiority[c]	Superiority/Inferiority[d]
IKDC Subjective Score	62	88.9 (13.2)	34	84.8 (13.2)	4.1 (–1.5 to 9.7)	<.001	.15
AP knee laxity, mm	58	1.61 (3.16)	32	1.77 (2.79)	–0.15 (–1.48 to 1.17)	<.001	.82

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TABLE 4
IKDC Objective Score Outcomes at 2 Years After Surgery[a]

	BEAR	ACLR	*P* Value
Effusion	57	30	.48
A	53 (93)	29 (97)	
B	4 (7)	1 (3)	
C	0 (0)	0 (0)	
D	0 (0)	0 (0)	
Range of motion	60	33	.42
A	32 (53)	18 (55)	
B	20 (33)	13 (39)	
C	5 (8)	2 (6)	
D	3 (5)	0 (0)	
Lachman	56	30	.41
A	52 (93)	27 (90)	
B	3 (5)	1 (3)	
C	1 (2)	2 (7)	
D	0 (0)	0 (0)	
Pivot	51[b]	25	.19
A	41 (80)	23 (92)	
B	10 (20)	2 (8)	
C	0 (0)	0 (0)	
D	0 (0)	0 (0)	
Overall[c]	50	25	.64
A	19 (38)	11 (44)	
B	25 (50)	11 (44)	
C	5 (10)	3 (12)	
D	1 (2)	0 (0)	

TABLE 5
Functional Measures at 2 Years After Surgery[a]

	BEAR		ACLR			
	No.	Mean (SD)	No.	Mean (SD)	Mean Difference (95% CI)[b]	*P* Value
Index						
Hamstring	59	98.2 (26.5)	31	63.2 (15.5)	35.0 (26.1 to 43.8)	<.001
Quadriceps	59	100.1 (12.2)	31	101.5 (12.4)	−1.4 (−6.6 to 4.0)	.61
Hamstring:quadriceps ratio (surgical side)	59	0.43 (0.12)	32	0.27 (0.08)	0.16 (0.11 to 0.21)	<.001
Hip abductor index	56	105.3 (15.3)	31	107.9 (22.5)	−2.6 (−11.7 to 6.6)	.58
Hop						
Single-leg	42	94.4 (13.0)	23	96.9 (13.4)	−2.4 (−9.2 to 4.4)	.48
Triple	41	94.9 (9.7)	22	98.0 (6.9)	−3.0 (−7.7 to 1.6)	.20
6-m timed	40	103.9 (10.6)	22	98.0 (6.7)	5.9 (1.5 to 10.3)	.009
Crossover	39	96.6 (9.8)	22	96.0 (7.3)	0.6 (−4.2 to 5.4)	.81

TABLE 6
Additional Ipsilateral and Contralateral Knee Surgical Procedures Within the First 2 Postoperative Years for the BEAR and ACLR Groups[a]

	BEAR (n = 64)	ACLR (n = 35)	*P* Value
Ipsilateral ACL surgery—all	9 (14.1)	2 (5.7)	.32
Isolated	1 (1.6)	1 (2.9)	≥.99
With meniscus	8 (12.5)	1 (2.9)	.15
Non-ACL ipsilateral knee surgery			
Arthrofibrosis	0 (0.0)	2 (5.7)	.12
Meniscus	7 (10.9)	2 (5.7)	.49
Removal of hardware	1 (1.6)	0 (0.0)	≥.99
Total patients with ipsilateral knee surgery[b]	16 (25.0)	5 (14.3)	.30
Contralateral ACL surgery	2 (3.1)	1 (2.9)	≥.99

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POST-OP PROTOCOL BEAR

BEAR® Implant Rehabilitation Protocol

Weight Bearing Status:

- Partial Weight Bearing
- Brace locked in extension for partial weight bearing for 4 weeks
- With clearance from PT and surgeon, patient may advance to WBAT with crutch wean at 4 weeks, only if the following criteria are met.
    - able to walk with normal gait pattern
    - no pain
    - no extensor lag
    - good quad control
    - ability to safely ascend/descend stairs without noteworthy pain or instability

Bracing Instructions:

ACL hinged knee brace (TROM or equivalent) for weight bearing activities.

- Locked for ambulation at 0 degrees for the first 4 weeks post-op
- Locked for sleep at 0 degrees for first 6 weeks post-op
- Unlock for range of motion (ROM) to specified degrees when seated or at physical therapy for gait training after 2 weeks
- Advance to unlocked brace for PWB ambulation at week 4 if the patient is comfortable doing so and if they demonstrate appropriate quadriceps control (should not flex past 90-degrees until week 6)

Brace Range:

Timeframe	Degree Range
First 24 hours only	Brace locked at 0° or until 1st post-op surgeon visit for adolescents
0 to 2 Weeks	0 - 45°
2 to 4 Weeks	0 - 90°
4 to 6 Weeks	Progress to full ROM as tolerated
6 to 14 Weeks	Change to functional brace (if requested by surgeon) when Active Range of Motion (AROM) is 0 to ≥110°

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POST-OP PROTOCOL BEAR

Phase 7: Weeks 36 to 52
Return-to-Sport Phase

GOALS
1. 90% contralateral quad strength
2. 90% contralateral on hop tests
3. Sport specific training without pain, swelling or difficulty

RECOMENDATION

Area	Instructions
Strengthening	• Squats • Lunges • Plyometrics
Sports Specific Activities	• Interval training programs • Running patterns in football • Sprinting • Change of direction • Pivot and drive-in basketball • Kicking in soccer • Spiking in volleyball • Skill / biomechanical analysis with coaches and sports medicine team
Return-To-Sports Evaluation Recommendations	• Balance test – single leg balance for 60 seconds without touchdown for each leg • Single leg squat – get to 60 degrees of flexion, able to do without IR at the hip or valgus at the knee • Hop tests (single leg hop for distance) to be 95% of contralateral side • QI > or = to 90%

★	**Return-to-Team Training Criteria**
	No functional complaints
	Confidence when running, cutting, jumping at full speed
	90% contralateral values on hop tests
	90% QI
	IKDC Question # 10 (Global Rating of Knee Function) of ≥ 9 *(Suggested Criteria, See page 12)*
	Clearance by operating surgeon

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QUESTIONS?

Thank you!

ACL Repair: The Beginnings

- Feagin and Curl, 1972
  - 2 year follow-up: 25 of 30 patients with good to excellent results

0363-5465/82/1002-0103$02.00/0
THE AMERICAN JOURNAL OF SPORTS MEDICINE, Vol. 10, No. 2

Primary surgical treatment of anterior cruciate ligament lesions*

JOHN L. MARSHALL,† DVM, MD, FACS, RUSSELL F. WARREN,‡ MD, FACS, AND THOMAS L. WICKIEWICZ,§‖ MD

1900 → 1910 → 1920 → 1930 → 1940 → 1950 → 1960 → 1970 → 1980 → 1990

CONCERNING MID TERM RESULTS

THE AMERICAN JOURNAL OF SPORTS MEDICINE, Vol. 4, No. 3

Isolated tear of the anterior cruciate ligament: 5-year follow-up study

JOHN A. FEAGIN, JR., M.D., COLONEL, AND WALTON W. CURL, M.D., MAJOR

From the Orthopaedic Service, United States Army Hospital, West Point, New York, and the Orthopaedic Service, Letterman Army Medical Center, San Francisco, California

1900 → 1910 → 1920 → 1930 → 1940 → 1950 → 1960 → 1970 → 1980 → 1990

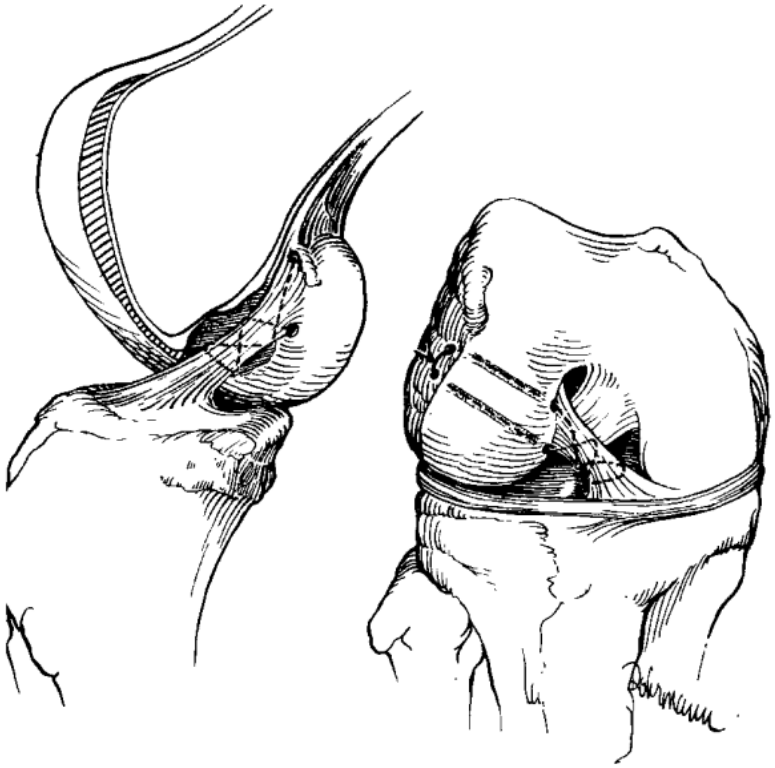

Figure 1—*Drawing illustrates method of surgical repair of anterior cruciate ligament. After a figure eight suture is made in the ligament, the suture is passed through drill holes in the lateral condyle and secured.*

TABLE I Functional Evaluation

Parameter	Cadets affected (n = 32)
Military duty	
Full duty	22
Ranger airborne	23
Combat duty	16
Athletic endeavors	
Impairment of ordinary activity	24
Ordinary activity	
Impairment	12
Subjective ratings (%)	
Pain	71
Swelling	66
Stiffness	71
Instability	94

RECONSTRUCTION > REPAIR?

0363-5465/90/1805-0484$02.00/0
THE AMERICAN JOURNAL OF SPORTS MEDICINE, Vol. 18, No. 5

Anterior cruciate ligament injury: Evaluation of intraarticular reconstruction of acute tears without repair

Two to seven year followup of 155 athletes*

K. DONALD SHELBOURNE,† MD, H. JEFFREY WHITAKER, MD, JOHN R. McCARROLL, MD, ARTHUR C. RETTIG, MD, AND LYNNE D. HIRSCHMAN, MS, PT

From the Methodist Sports Medicine Center, Indianapolis, Indiana

1900 → 1910 → 1920 → 1930 → 1940 → 1950 → 1960 → 1970 → 1980 → 1990

RECONSTRUCTION > REPAIR?

The Journal of
Bone and Joint Surgery

American Volume

VOLUME 78-A, NO. 2 FEBRUARY 1996

A Prospective, Randomized Study of Three Operations for Acute Rupture of the Anterior Cruciate Ligament

FIVE-YEAR FOLLOW-UP OF ONE HUNDRED AND THIRTY-ONE PATIENTS*

BY TORBJØRN GRØNTVEDT, M.D.†, LARS ENGEBRETSEN, M.D., PH.D.‡, PÅL BENUM, M.D., PH.D.†, TRONDHEIM, OVE FASTING, M.D.§, OSLO, ANDERS MØLSTER, M.D., PH.D.¶, AND TORBJØRN STRAND, M.D.¶, BERGEN, NORWAY

Investigation performed at the Department of Orthopaedic Surgery, Trondheim University Hospital, Trondheim; the Department of Orthopaedic Surgery, Aker Hospital, University of Oslo, Oslo; and the Department of Orthopaedic Surgery, Haukeland Hospital, University of Bergen, Bergen

The findings of this study reinforce the conclusions of our two-year follow-up report that a non-augmented primary repair should not be performed, a repair with a ligament-augmentation device has an unacceptably high rate of failure (more than one-third of the patients), and a repair that is augmented with the patellar ligament has the best outcome.

1900 → 1910 → 1920 → 1930 → 1940 → 1950 → 1960 → 1970 → 1980 → 1990

THE REIGN OF ACL RECONSTRUCTION

1900 → 1910 → 1920 → 1930 → 1940 → 1950 → 1960 → 1970 → 1980 → 1990 → 2000 → 2010 → 2020

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RENEWED INTEREST

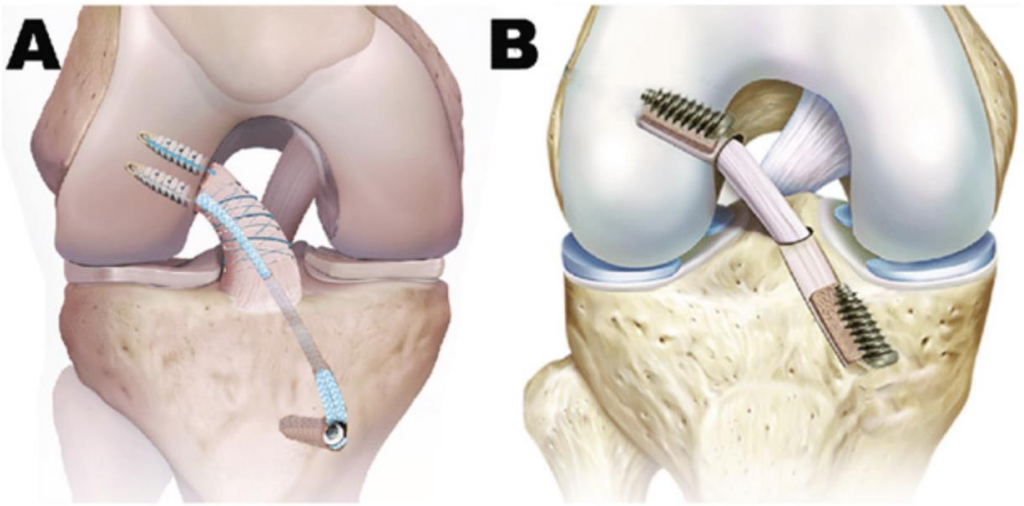

Figure 1: Principle of ACL primary repair (A) (shown with internal brace) vs. ACL reconstruction with a tendon graft (B)

Bostonjointpreservation.com

1980 → 1990 → 2000 → 2010 → 2020 → BEYOND

The New York Times

PERSONAL HEALTH

For a Torn A.C.L., Considering Repair Rather Than Replacement

Repair may be especially helpful for children, who are more likely than older patients to reinjure a reconstructed A.C.L., a pioneer of the surgery says.

ITGERS

BARRIERS TO ACL REPAIR

- Mechanical environment
  - Improved with newer devices
- **Biologic environment**
  - Hostile synovial fluid environment
  - Alteration of cellular metabolism after injury
  - Intrinsic cell deficiencies
  - Poor blood supply

MURRAY AND THE BEAR

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HOW DOES THE ACL HEAL

- After rupture…
  - Cells proliferate
  - Revascularization
  - Collagen production oc
- The ACL can heal! In th right environment…
  - Intra-articular vs. extra-articular

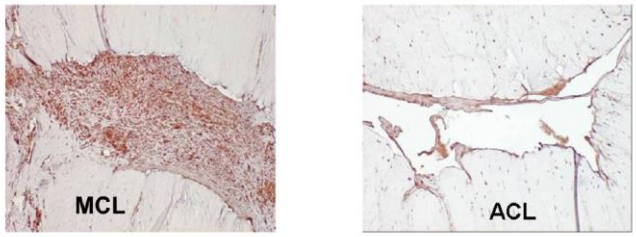

Figure 4.
Representative micrographs of slit wounds made with a modified Beaver blade in the center of the MCL and ACL seven days earlier in a canine knee. Note that the MCL wound is filled with a provisional scaffolding material containing high amounts of multiple growth factors important in tissue healing (here, immunohistochemistry for FGF-2 where red is a positive stain). In the ACL wound, however, the defect remains unfilled, even after seven days. *(Adapted with permission from Steiner, ME, Murray, M.M. and Rodeo, S.A. Strategies to Improve Anterior Cruciate Ligament Healing and Graft Placement, American Journal of Sports Medicine, 2008, 36(10), pages 176–8923.)*

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Bone Joint Res. 2014 Feb 4;3(2):20-31. doi: 10.1302/2046-3758.32.2000241. Print 2014.

Basic science of anterior cruciate ligament injury and repair

A M Kiapour [1], M M Murray

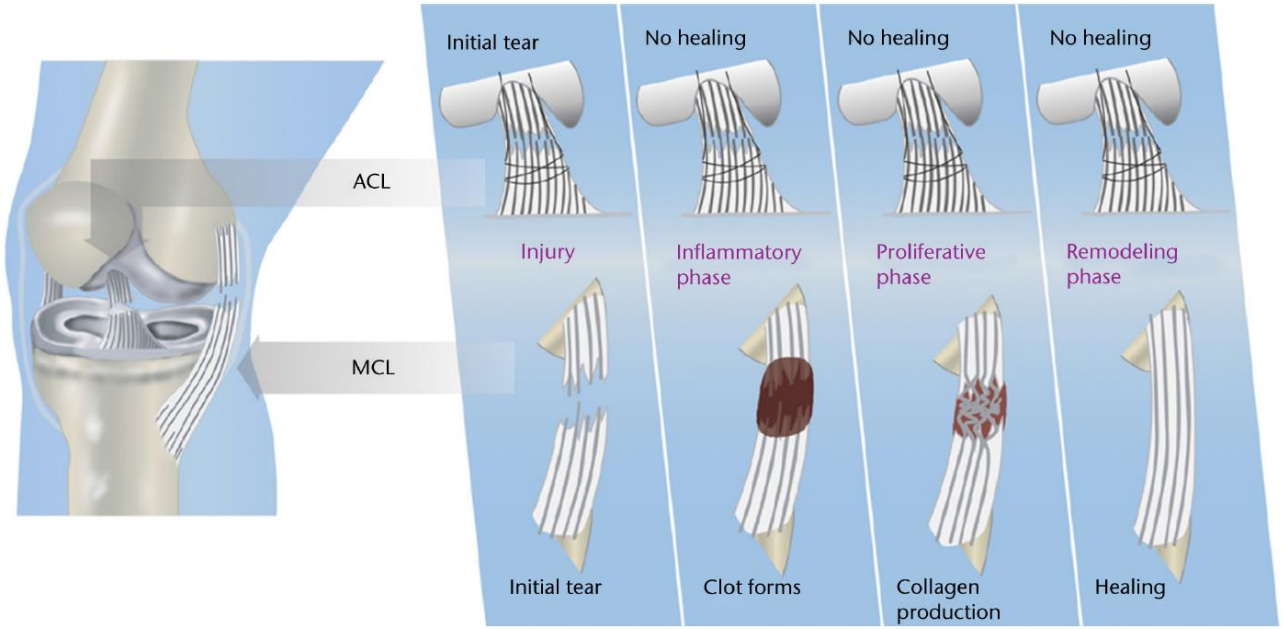

Fig. 2

Diagrams showing the differences in intrinsic healing response of the anterior cruciate ligament (ACL; top) and medial collateral ligament (MCL; bottom), highlighting the lack of provisional scaffold (blood clot) formation within the ACL wound site as the key mechanism for ACL healing failure (reproduced with permission from Murray and Fleming[63]).

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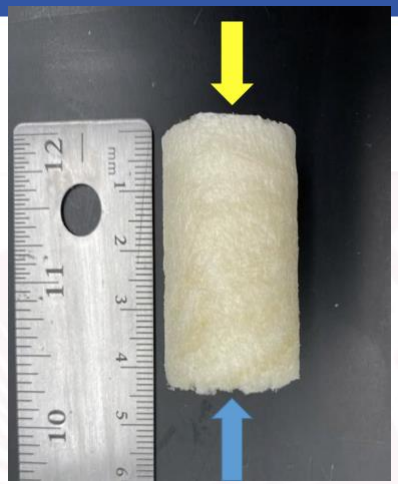
Review > Ann Biomed Eng. 2015 Mar;43(3):805-18. doi: 10.1007/s10439-015-1257-z. Epub 2015 Jan 29.

Bridge-enhanced ACL repair: A review of the science and the pathway through FDA investigational device approval

Benedikt L Proffen [1], Gabriel S Perrone, Gordon Roberts, Martha M Murray

- Basic science → in vitro, in vivo studies
  - Cell Seeding
  - Growth Factors
  - Scaffolds
- FDA Investigational Device Approval
  - Safety, consistency, sterility, biocompatibility
  - Investigational device exemption (IDE)

BEAR IMPLANT



- Scaffold
  - Extracellular matrix proteins, including collagen, from bovine tissue
  - Low DNA content, not cross-linked
  - 22mm diameter, 45mm length
  - Hydrophilic, can absorb up to 5 times its weight
  - Softens when blood added, moldable
- Absorbs in about 8 weeks
- Forms device protected clot to to allow healing

McMillan et al.

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The Bridge-Enhanced Anterior Cruciate Ligament Repair (BEAR) Procedure

An Early Feasibility Cohort Study

Martha M. Murray,*† MD, Brett M. Flutie,† BA, Leslie A. Kalish,‡ ScD, Kirsten Ecklund,§ MD, Braden C. Fleming,‖ PhD, Benedikt L. Proffen,† MD, and Lyle J. Micheli,† MD

Investigation performed at Boston Children's Hospital, Boston, Massachusetts, USA

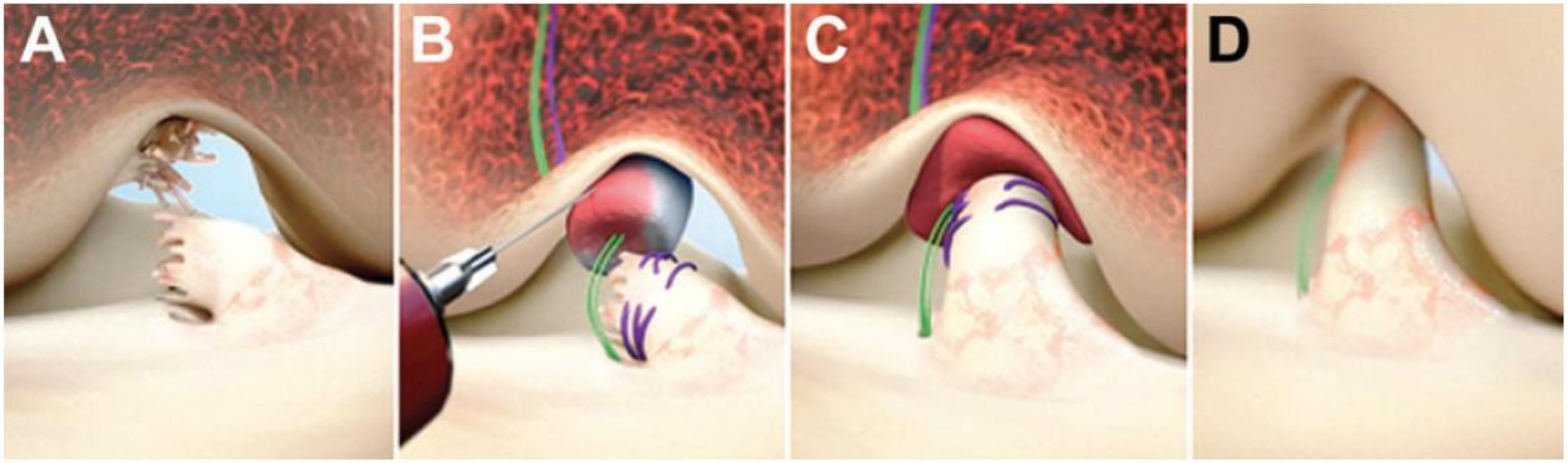

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TABLE 1
Baseline Characteristics[a]

	BEAR Group (n = 10)	ACLR Group (n = 10)	P
Male sex, n	4	2	
White (non-Hispanic) ethnicity, n	7	8	
Age, y	24.1 ± 4.9 (18.1-34.6)	24.6 ± 5.5 (18.6-33.8)	
Body mass index, kg/m^2	24.2 ± 2.0 (21.5-28.1)	25.1 ± 2.9 (20.0-30.0)	
Time from injury to surgery, d	20.8 ± 4.8 (11.0-28.0)	52.9 ± 16.7 (24.0-80.0)	<.001
Left knee injured, n	5	6	
Sports injury mechanism, n	10	9	
Noncontact injury, n	9	9	
MRI findings, n			
Torn posterior cruciate ligament	0	0	
Torn medial collateral ligament	0	1	

[a]Data are presented as mean ± SD (range) unless otherwise indicated. Previously published with 3-month data for this cohort.[41] ACLR, anterior cruciate ligament reconstruction; BEAR, bridge-enhanced anterior cruciate ligament repair; MRI, magnetic resonance imaging.

TABLE 2
Intraoperative Findings[a]

	BEAR (n = 10)	ACLR (n = 10)	P
Length of ACL tibial remnant, n			.13
0%-24%	0	0	
25%-49%	0	0	
50%-74%	9	6	
≥75%	1	4	
Meniscal tear (≥1),[b] n	4	5	
Medial (excised/repaired)	2 (0/2)	1 (0/1)	
Lateral (excised/repaired)	2 (1/1)	4 (0/4)	
Effusion grade (0-3)[c]	1.3 ± 0.7	0.9 ± 0.8	
Side-to-side difference in Lachman test result,[c] mm	5.2 ± 1.4	5.0 ± 2.5	
Pivot-shift test result, n			
Glide	2	3	
Clunk	8	7	

[a]Data are presented as mean ± SD unless otherwise indicated. ACL, anterior cruciate ligament; ACLR, anterior cruciate ligament reconstruction; BEAR, bridge-enhanced anterior cruciate ligament repair.

[b]BEAR group: 1 lateral tear in 1 patient, 2 lateral tears in 1 patient, and 1 medial tear in 2 patients. ACLR group: 1 lateral tear in 3 patients, 2 lateral tears in 1 patient, and 1 medial tear in 1 patient.

[c]n = 9 in ACLR group.

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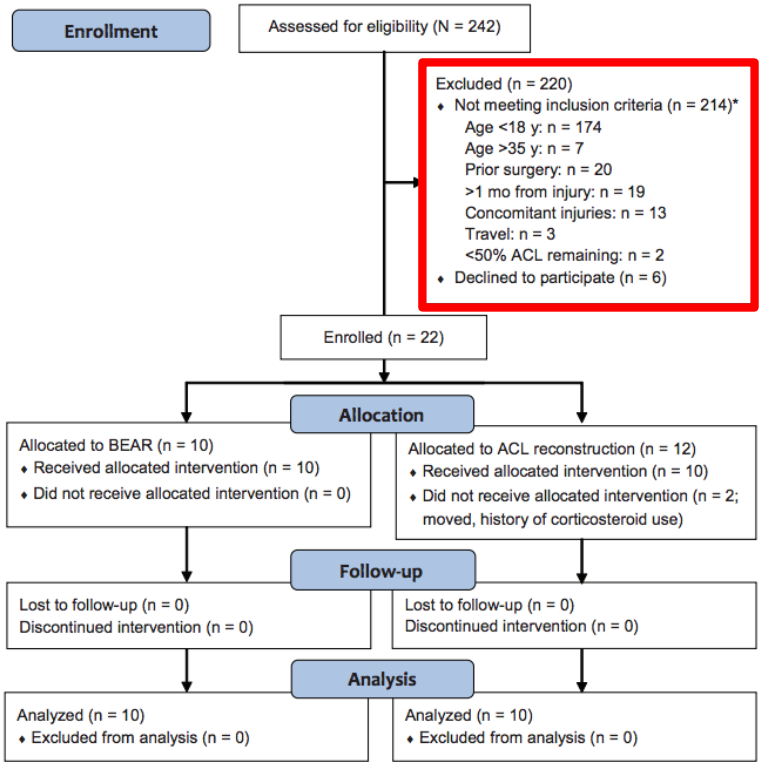

Figure 1. CONSORT 2010 flow diagram. *The total number of patients not meeting inclusion criteria totals to greater than 214, as some patients met more than 1 exclusion criterion. ACL, anterior cruciate ligament; BEAR, bridge-enhanced ACL repair.

TABLE 4
Outcomes Measured Only at 3 Months or Measured as Time Duration[a]

Outcome	Mean ± SD or n
Lachman laxity difference, mm[b]	
BEAR	1.10 ± 1.45
Grade A, n	8
Grade B, n	2
ACLR	0.60 ± 0.97
Grade A, n	10
Grade B, n	0
Hamstring strength, % contralateral[c]	
BEAR	77.9 ± 14.6
ACLR	55.9 ± 7.8
Hip abduction, % contralateral	
BEAR	95.4 ± 10.9
ACLR	96.8 ± 10.3
IKDC score (0-100)	
BEAR	54.3 ± 6.4
ACLR	60.7 ± 10.2
Return to school/work, wk	
BEAR	3.1 ± 3.3
ACLR	4.0 ± 4.2
Time using crutches, wk	
BEAR	4.7 ± 1.3
ACLR	4.8 ± 1.7
Thigh circumference 5 cm above patella, % contralateral	
BEAR	98.3 ± 1.7
ACLR	98.7 ± 2.5
Thigh circumference 10 cm above patella, % contralateral	
BEAR	94.1 ± 2.8
ACLR	95.4 ± 3.1

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Bridge-Enhanced Anterior Cruciate Ligament Repair

Two-Year Results of a First-in-Human Study

Martha M. Murray,* MD, Leslie A. Kalish, ScD, Braden C. Fleming, PhD, BEAR Trial Team, Benedikt L. Proffen, MD, Kirsten Ecklund, MD, Dennis E. Kramer, MD, Yi-Meng Yen, MD, PhD, and Lyle J. Micheli, MD

Investigation performed at Boston Children's Hospital, Boston, Massachusetts, USA

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TABLE 4
Side-to-Side Differences in Anteroposterior Laxity (mm)[a]

	ACLR Group	BEAR Group	Difference,[b] Mean (95% CI)
6 mo	0.78 ± 1.97 (n = 9)	2.36 ± 1.81 (n = 10)	1.58 (–0.25 to 3.40)
12 mo	0.91 ± 3.17 (n = 8)	1.20 ± 1.88 (n = 10)	0.29 (–2.25 to 2.84)
24 mo	3.14 ± 2.66 (n = 7)	1.94 ± 2.08 (n = 8)	–1.21 (–3.85 to 1.44)

[a]Data are presented as mean ± SD unless otherwise indicated. ACLR, anterior cruciate ligament reconstruction; BEAR, bridge-enhanced anterior cruciate ligament repair.
[b]Positive difference favors ACLR, and negative difference favors BEAR.

TABLE 5
IKDC Objective Grades[a]

	A	B	C	D	Total
Preoperative					
BEAR	0 (0)	0 (0)	5 (50)	5 (50)	10 (100)
ACLR	0 (0)	0 (0)	6 (60)	4 (40)	10 (100)
6 mo					
BEAR	1 (10)	8 (80)	1 (10)	0 (0)	10 (100)
ACLR	3 (33)	6 (67)	0 (0)	0 (0)	9 (100)
12 mo					
BEAR	6 (60)	4 (40)	0 (0)	0 (0)	10 (100)
ACLR	2 (25)	5 (62.5)	1 (12.5)	0 (0)	8 (100)
24 mo					
BEAR	4 (44)	5 (56)	0 (0)	0 (0)	9 (100)
ACLR	2 (29)	5 (71)	0 (0)	0 (0)	7 (100)

[a]Data are presented as n (%). ACLR, anterior cruciate ligament reconstruction; BEAR, bridge-enhanced anterior cruciate ligament repair; IKDC, International Knee Documentation Committee.

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TABLE 6
Functional Outcomes[a]

	ACLR Group	BEAR Group	Difference,[b] Mean (95% CI)
Prone hamstring strength[c]			
6 mo	64.3 ± 14.5 (n = 9)	89.5 ± 13.8 (n = 10)	25.1 (11.4 to 38.9)
12 mo	59.8 ± 23.9 (n = 8)	92.7 ± 20.4 (n = 10)	32.9 (10.8 to 55.0)
24 mo	56.3 ± 19.0 (n = 7)	98.6 ± 10.5 (n = 8)	42.3 (25.5 to 59.1)
Seated quadriceps strength			
6 mo	90.1 ± 15.4 (n = 9)	87.4 ± 26.5 (n = 10)	2.7 (–24.0 to 18.6)
12 mo	96.4 ± 26.6 (n = 8)	83.2 ± 22.0 (n = 10)	–13.2 (–37.4 to 11.1)
24 mo	103.1 ± 13.3 (n = 7)	98.5 ± 11.2 (n = 8)	–4.6 (–18.3 to 9.1)
Lying hip abductor strength			
6 mo	101.2 ± 11.4 (n = 9)	97.7 ± 8.2 (n = 10)	–3.5 (–13.0 to 6.1)
12 mo	96.9 ± 18.0 (n = 8)	105.4 ± 6.6 (n = 10)	8.5 (–4.5 to 21.4)
24 mo	91.2 ± 26.1 (n = 7)	106.3 ± 15.3 (n = 7)	15.1 (–9.8 to 40.0)
Peak flexor torque at 60 deg/s			
6 mo	79.7 ± 16.7 (n = 9)	89.5 ± 18.3 (n = 9)	9.8 (–7.7 to 27.4)
12 mo	85.0 ± 10.2 (n = 8)	84.3 ± 19.2 (n = 10)	–0.7 (–16.8 to 15.3)
24 mo	80.9 ± 21.0 (n = 6)	96.3 ± 12.2 (n = 7)	15.4 (–5.1 to 36.0)
Single hop			
6 mo	84.2 ± 14.2 (n = 8)	64.5 ± 21.8 (n = 9)	–19.7 (–39.0 to –0.4)
12 mo	93.4 ± 12.0 (n = 4)	77.4 ± 19.0 (n = 9)	–16.0 (–39.0 to 7.0)
24 mo	83.9 ± 8.3 (n = 6)	88.8 ± 10.7 (n = 6)	4.9 (–7.4 to 17.2)
Triple hop			
6 mo	85.5 ± 10.8 (n = 8)	73.8 ± 18.9 (n = 6)	–11.7 (–29.1 to 5.6)
12 mo	92.0 ± 8.8 (n = 4)	82.1 ± 14.0 (n = 8)	–9.9 (–27.2 to 7.4)
24 mo	93.8 ± 9.9 (n = 6)	94.2 ± 6.4 (n = 6)	0.5 (–10.2 to 11.2)
6-m timed single hop			
6 mo	113.7 ± 9.0 (n = 8)	119.1 ± 15.7 (n = 7)	5.5 (–8.6 to 19.5)
12 mo	101.2 ± 11.0 (n = 4)	118.4 ± 24.7 (n = 9)	17.1 (–11.7 to 46.0)
24 mo	102.2 ± 12.0 (n = 6)	112.4 ± 13.3 (n = 6)	10.2 (–6.2 to 26.5)
Crossover single-leg hop			
6 mo	85.9 ± 9.7 (n = 8)	81.6 ± 18.8 (n = 5)	–4.3 (–21.5 to 12.9)
12 mo	94.4 ± 11.6 (n = 4)	85.7 ± 9.9 (n = 6)	–8.7 (–24.4 to 7.1)
24 mo	95.0 ± 2.9 (n = 6)	94.2 ± 5.7 (n = 6)	–0.8 (–6.6 to 5.0)
Single-leg squat >60° (operative side), n (%)			
6 mo	8/9 (88.9)	6/10 (60.0)	–28.9 (–67.6 to 14.1)
12 mo	7/8 (87.5)	10/10 (100.0)	12.5 (–34.9 to 56.1)
24 mo	6/7 (85.7)	8/9 (88.9)	3.2 (–43.5 to 49.8)

[a]Data are presented as mean ± SD unless otherwise indicated. Strength and hop testing results are presented as percentages of the contralateral leg. ACLR, anterior cruciate ligament reconstruction; BEAR, bridge-enhanced anterior cruciate ligament repair.

[b]Positive difference favors BEAR, and negative difference favors ACLR, for all outcomes except the 6-m timed single hop and single-leg squat >60°.

[c]Hamstring strength was significantly better in the BEAR group than in the ACLR group at all time points ($P < .05$ for comparison between groups at all time points).

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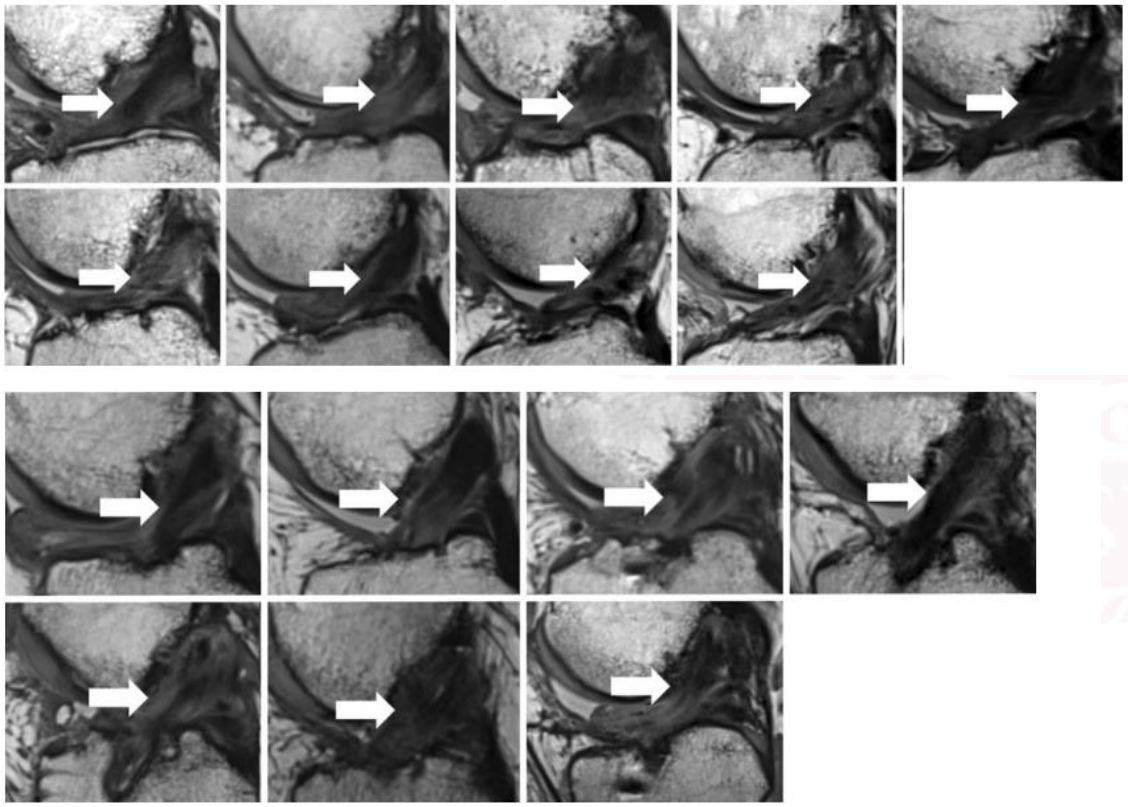
MRI – 24 MONTHS

BEAR

ACLR



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Winner of the O'Donoghue Award

Bridge-Enhanced Anterior Cruciate Ligament Repair Is Not Inferior to Autograft Anterior Cruciate Ligament Reconstruction at 2 Years

Results of a Prospective Randomized Clinical Trial

Martha M. Murray,* MD, Braden C. Fleming, PhD, Gary J. Badger, MS, The BEAR Trial Team, Dennis E. Kramer, MD, Lyle J. Micheli, MD, and Yi-Meng Yen, MD, PhD
Investigation performed at Boston Children's Hospital, Boston, Massachusetts, USA

PODCAST
In-Depth

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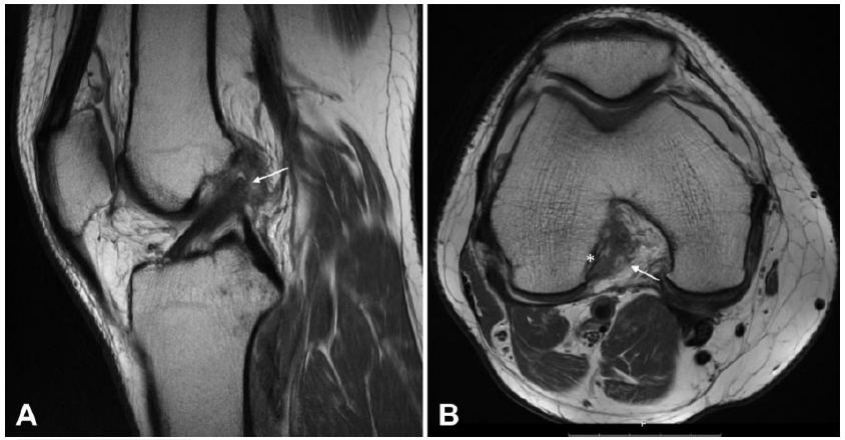
ACL RECONSTRUCTION FAR FROM PERFECT

- Re-tear rates
  - Multi-factorial but ranges from 2-20%
  - Higher prevalence in younger, more athletic patients
    - <20 yo, pivoting sport → 29-40% risk of re-rupture or contralateral ACL surgery
      - Gokeler et al.
- Return to sport
  - Variable but 81% return to any sport, 65% preinjury level, 55% competitive
    - Arden et al.
  - Psychological barriers
- Arthritis
  - No data proving that ACL reconstruction is superior to conservative management in the prevention of post-traumatic OA



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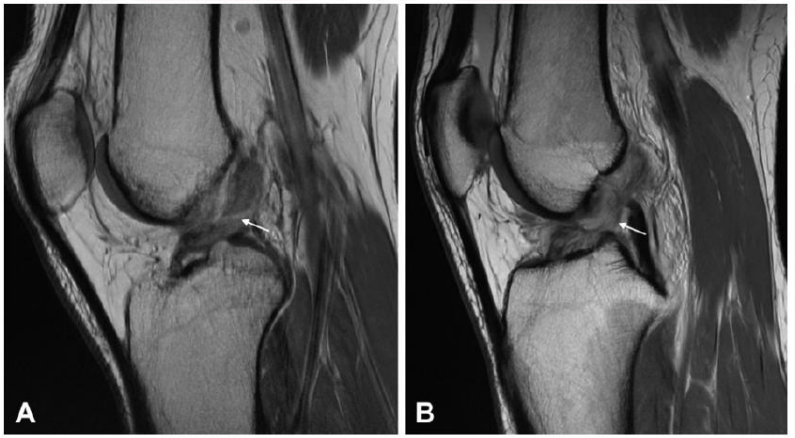
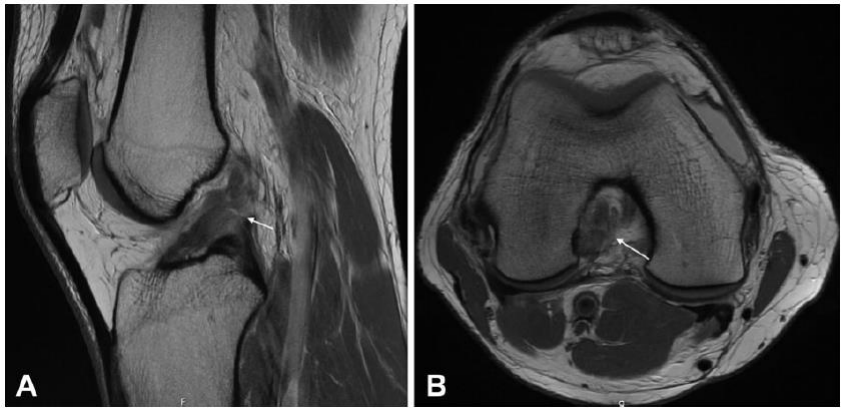
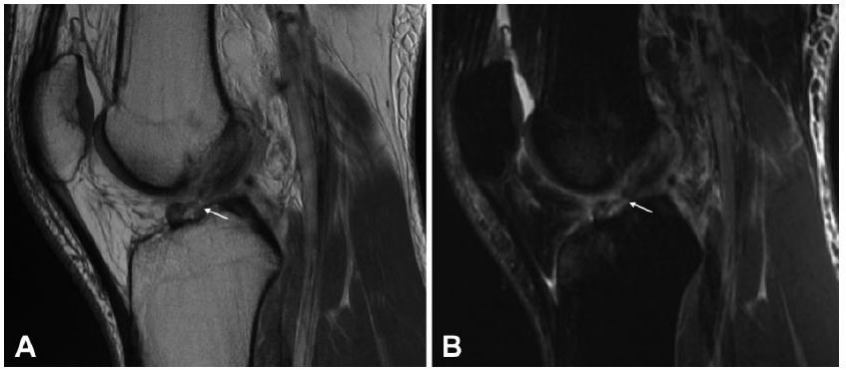


Type III



Type II



Type IV

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WHAT'S NEXT?

- 5-year BEAR data
- Finding and expanding indications?
  - Timing
  - How to determine viability of tibial stump?
  - Location of tear?
- Long term
  - Prevention of arthritis?
- Limitations of the current data
  - Heterogeneous groups, different techniques, low level studies, short term follow-up
  - Risk of bias → industry involvement
- New techniques or applications?

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