Poster 32

Drop Vertical Testing after Quadriceps, Hamstring, and BPTB Autografts in ACL Reconstruction

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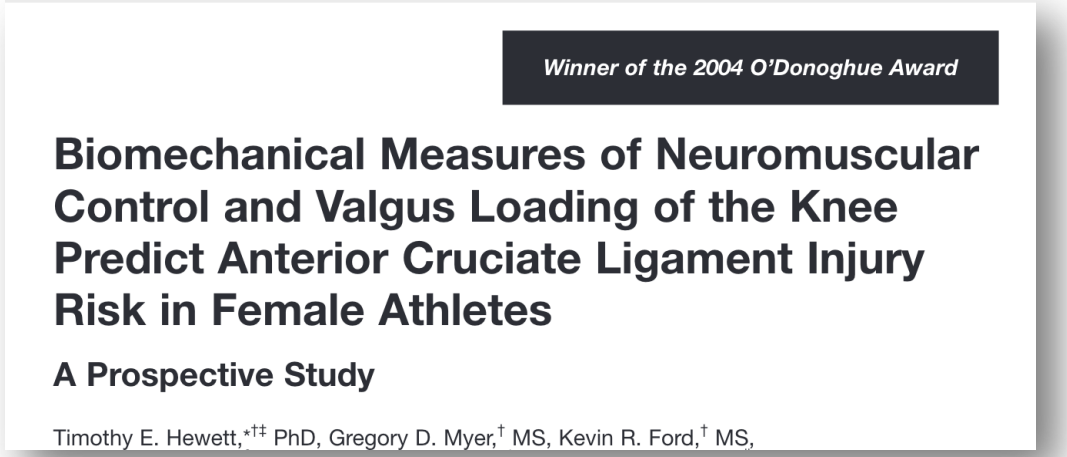
DISCLOSURES

- No Relevant Disclosures

BIOMECHANICS DEFINE CRITICAL RISK FACTORS



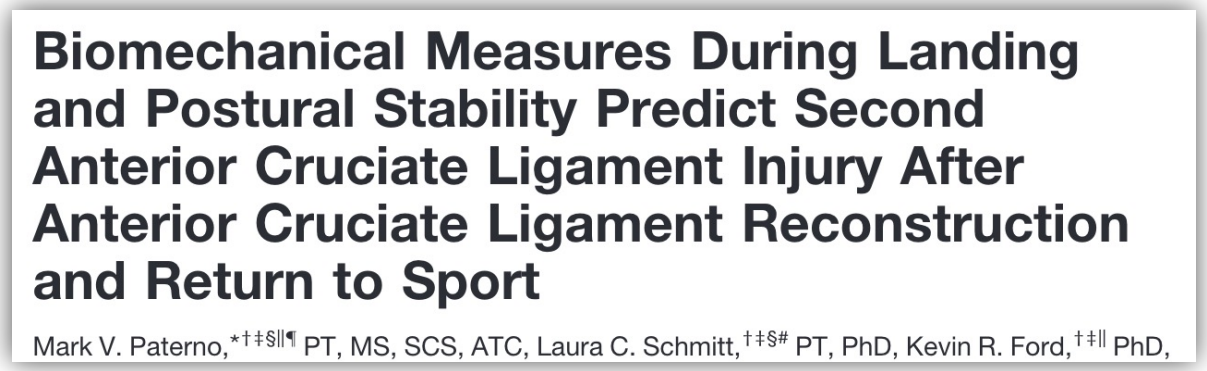
Winner of the 2004 O'Donoghue Award

Biomechanical Measures of Neuromuscular Control and Valgus Loading of the Knee Predict Anterior Cruciate Ligament Injury Risk in Female Athletes

A Prospective Study

Timothy E. Hewett,*†‡ PhD, Gregory D. Myer,† MS, Kevin R. Ford,† MS,

Patients with *primary* ACL tear landed with 10.5º greater knee extension and 8.4º greater knee valgus



Biomechanical Measures During Landing and Postural Stability Predict Second Anterior Cruciate Ligament Injury After Anterior Cruciate Ligament Reconstruction and Return to Sport

Mark V. Paterno,*†‡§‖¶ PT, MS, SCS, ATC, Laura C. Schmitt,†‡§# PT, PhD, Kevin R. Ford,†‡‖ PhD,

Patients with ACL *retear* landed in increased knee extension with increased frontal plane knee motion (valgus)

PURPOSE

- Compare *biomechanical outcomes* during a DVJ between common autograft types six-months after ACL reconstruction in an adolescent population
  - Hamstring (HS)
  - Quadriceps +/- Bone Block (QB, Q)
  - Bone-Patellar Tendon-Bone (BTB)
- Hypothesis
  - **There will be differences in biomechanical profiles between patients depending on autograft type used**

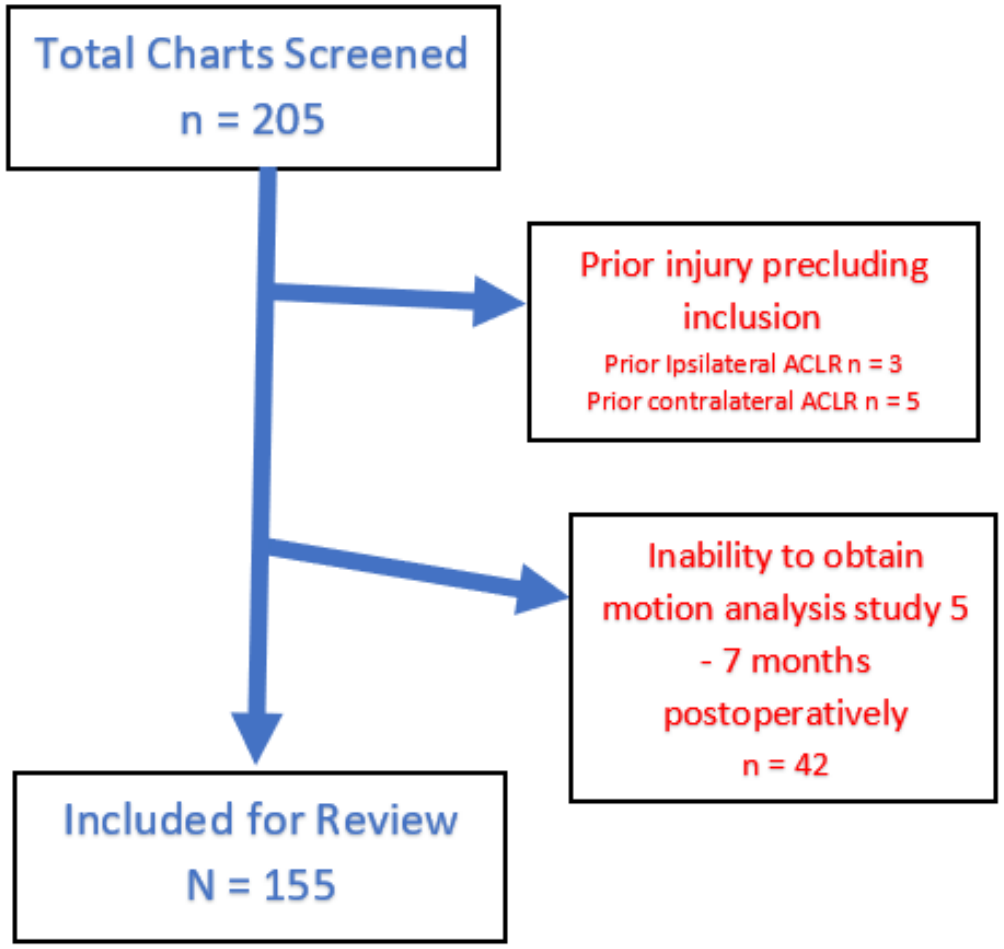
METHODS

METHODS

- Two board certified orthopedic sports medicine surgeons at single institution
- Prospective evaluation of patients 8-18 years old with first time ACL tear 6 months after reconstruction
- **4 Autograft Types**
  - Hamstring
  - Quadriceps +/- Bone Block
  - Bone-Patellar Tendon-Bone
- Chart review to collect age, sex, height, weight, affected limb, graft type, and mechanism of injury

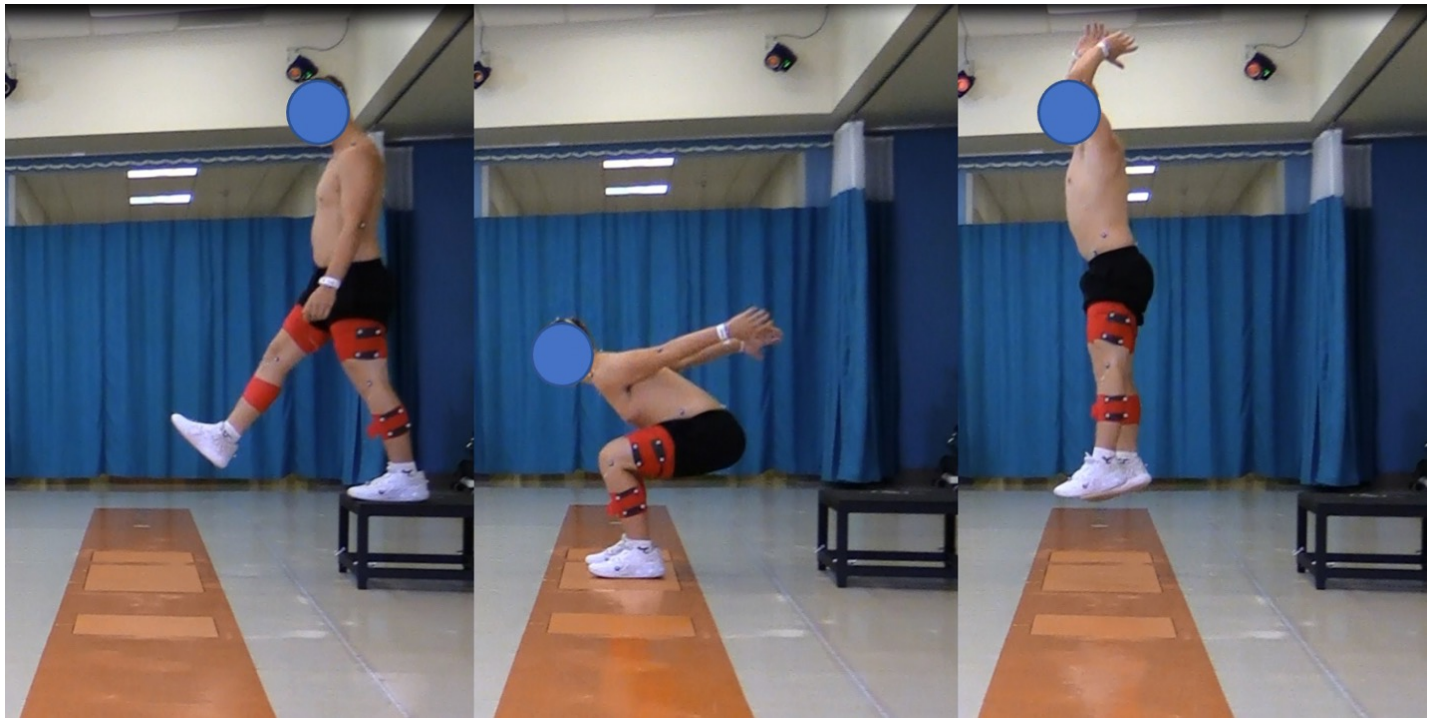
INCLUSION/EXCLUSION

- Inclusion
  - 8-18 y/o
  - First Time ACL Tear
- Exclusion
  - Preexisting joint disease
  - Hx of previous knee injury to either lower extremity
- **155 patients** included in final analysis



MOTION ANALYSIS

- Kinematic and kinetic data collected during a DVJ using a 3D computerized marker system (Motion Analysis Corp. CORTEX software)
- Evaluated biomechanical factors including hip internal rotation moment, hip adduction moment, knee valgus angles/moments, knee extensor moments among others



DATA ANALYSIS

- Operative limb was compared to Nonoperative limb
  - Standardized per mass for force related variables
- Average and Maximum Values calculated

$$Average\ Value = \frac{\sum_0^T Var_{affected\ limb} - \sum_0^T Var_{unaffected\ limb}}{M}$$

$$Maximum\ Value = \frac{Var_{affected\ limb}\ \|_{t=t_{max}} - Var_{unaffected\ limb}\ \|_{t=t_{max}}}{M}$$

RESULTS

PATIENT CLINICAL CHARACTERISTICS

- 205 patients screened, **155 included for analysis**
  - Hamstring → 54
  - Quad + Bone Block → 40
  - Quad without Bone Block → 35
  - BTB → 26
- Mean Age **15.8 y/o**
- No significant differences in age, sex, or affected leg between groups (p > 0.1973)

Table 1: Patient demographics and clinical characteristics by autograft group

	HS (n=54)	QB (n=40)	Q (n=35)	BTB (n=26)	Total (N=155)	P-value
Age (years)						
Mean (SD)	16.2 (2.02)	15.5 (2.0)	15.6 (1.6)	15.8 (1.4)	15.8 (1.89)	0.19732
Sex (Male)	26 (48.15%)	29 (42.5%)	19 (54.3%)	11 (42.3%)	85 (54.8%)	0.72241
Affected Leg (Right)	31 (57.4%)	16 (40.0%)	14 (40.0%)	14 (53.8%)	75 (48.4%)	0.71201
Height (cm)						
Mean (SD)	172.7 (11.8)	169.2 (8.8)	164.6 (9.25)	170.5 (8.8)	169.23 (11.4)	**<0.0001***
Weight (kg)						
Mean (SD)	77.9 (21.8)	64.1 (12.6)	69.1 (14.6)	77.9 (17.7)	73.13 (20.03)	0.00152
Body Mass Index (kg/m^2)						
Mean (SD)	26.0 (6.1)	22.2 (3.0)	25.5 (4.9)	26.7 (5.4)	25.8 (5.8)	0.00152
Mechanism of Injury						0.0331
Contact	44	26	19	17	106	
Noncontact	10	14	16	9	49	
None	0	0	0	0	0	

KNEE EXTENSION MOMENT

- *Quadriceps Autografts* with and without bone block have **significantly decreased knee extension moment averages and maximums** compared to Hamstring Autograft

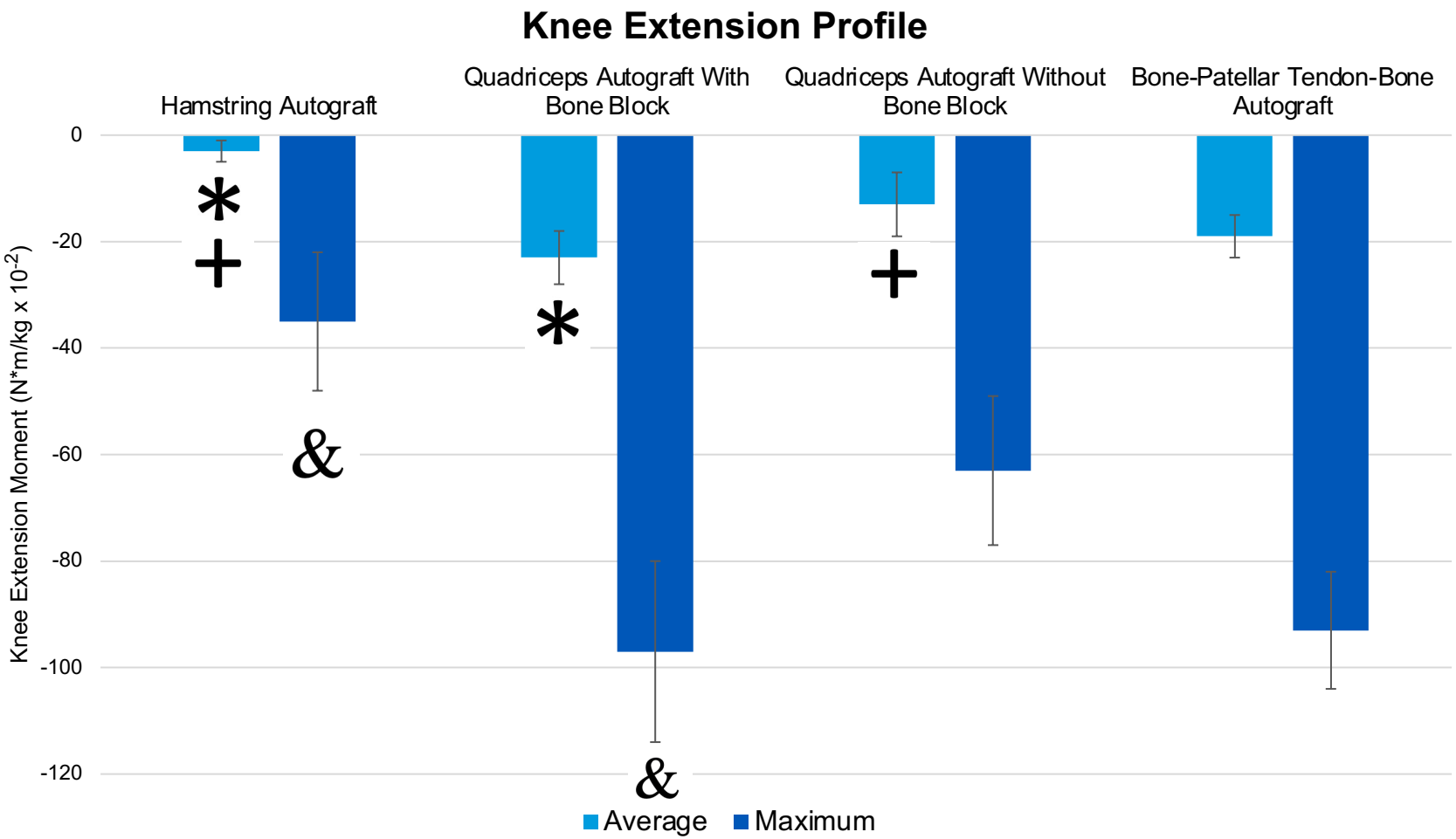


Figure 4: The knee extension moment average and maximum as compared between our 4 graft types. Significant differences are noted with an asterisk (*), plus (+), or ampersand (&) sign.

KNEE VALGUS MOMENT

- *Hamstring Autografts* are significantly associated with **larger knee valgus moments** at initial contact compared to Quadriceps Autograft Without Bone Block during DVJ

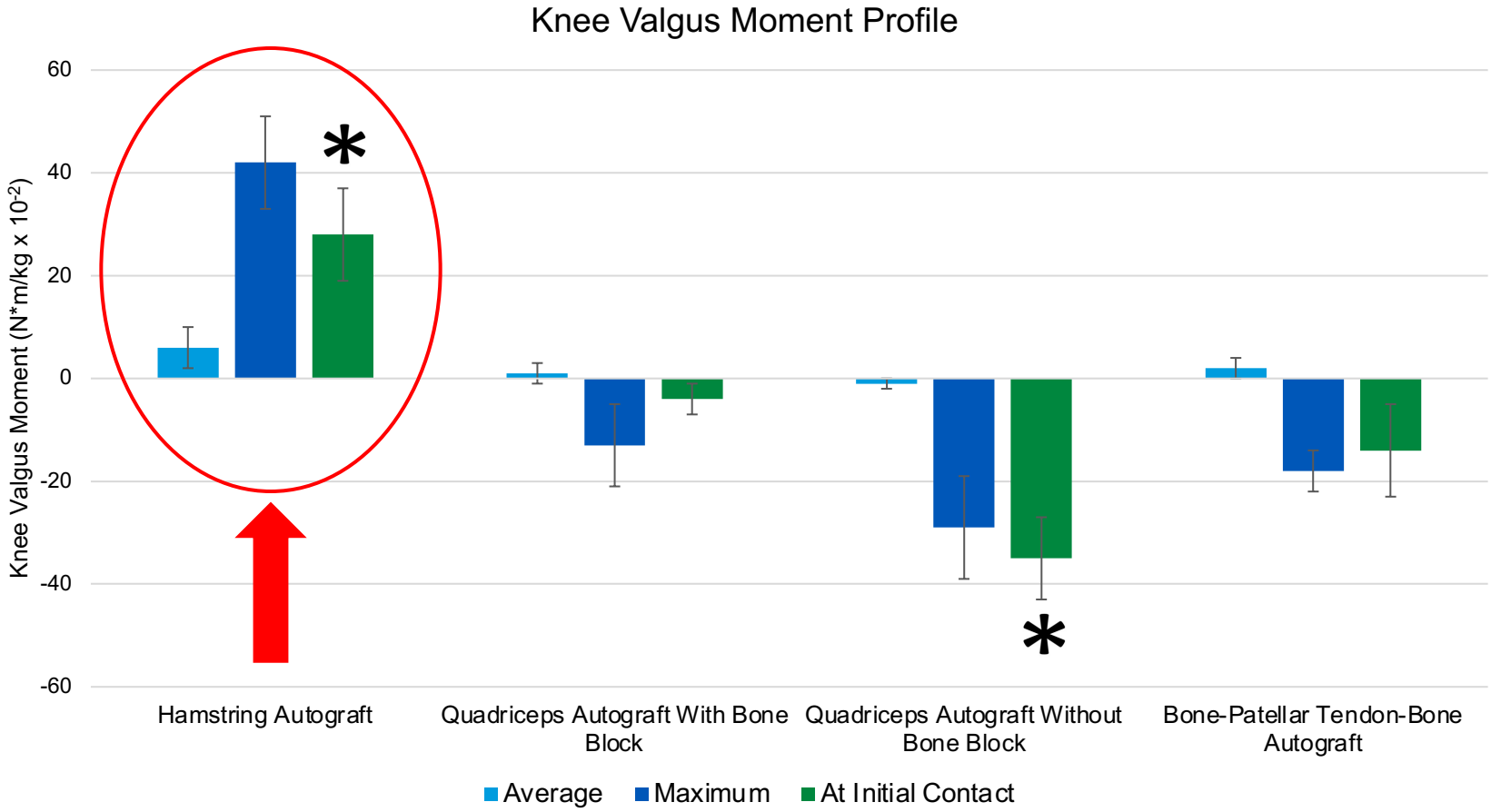


Figure 5: The knee valgus moment average, maximum, and at initial contact as compared between our 4 graft types. The overall group can be seen on the far right. Significant differences are noted with an asterisk (*).

HIP ADDUCTION AND TIBIAL INTERNAL ROTATION

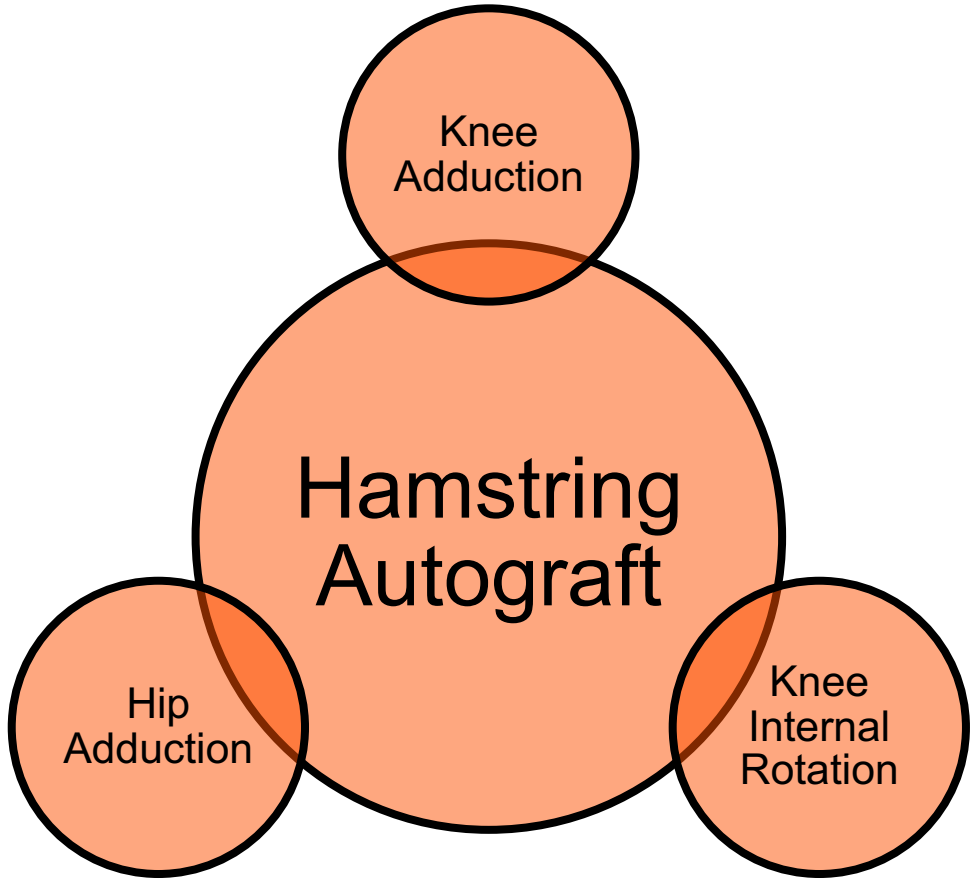
- Hamstring Autografts are significantly associated with **larger hip adduction maximums and knee internal rotation averages moments** compared to Quadriceps with Bone Block during DVJ

Parameter (Units)	HS Group	QB Group	Q Group	BTB Group	P-Value (Initial Kruskal Wallis)	Total	Follow-Up Dwass-Steel-Crichlow-Fligner Test	
Hip Adduction Moment (N*m/kg x 10^{-2})								
Average	2 (0.02)	-2 (0.02)	-3 (0.02)	-2 (0.02)	0.117	-1 (0.02)	N/A	N/A
Maximum	**30 (0.05)**	**-4 (0.04)**	9 (0.04)	-2 (0.02)	**0.033**	11 (0.05)	**HS & QB**	**0.0426**
Knee External Rotation Moment (N*m/kg x 10^{-2})								
Average	**-2 (0.02)**	**2 (0.02)**	2 (0.03)	1 (0.01)	**0.00871**	1 (0.02)	**H & QB**	**0.0206**
Maximum	4 (0.02)	2 (0.02)	1 (0.01)	2 (0.01)	0.98481	2 (0.01)	N/A	N/A

DISCUSSION

MAIN FINDINGS

- *Hamstrings Autograft* associated with **hip adduction, knee internal rotation and knee valgus** at 6 months after ACLR during DVJ
  - Dynamic knee valgus associated with increased risk of ACL retear in prior literature
- *Quadriceps Autografts* associated with **decreased extensor mechanism moments** at 6 months after ACLR during DVJ



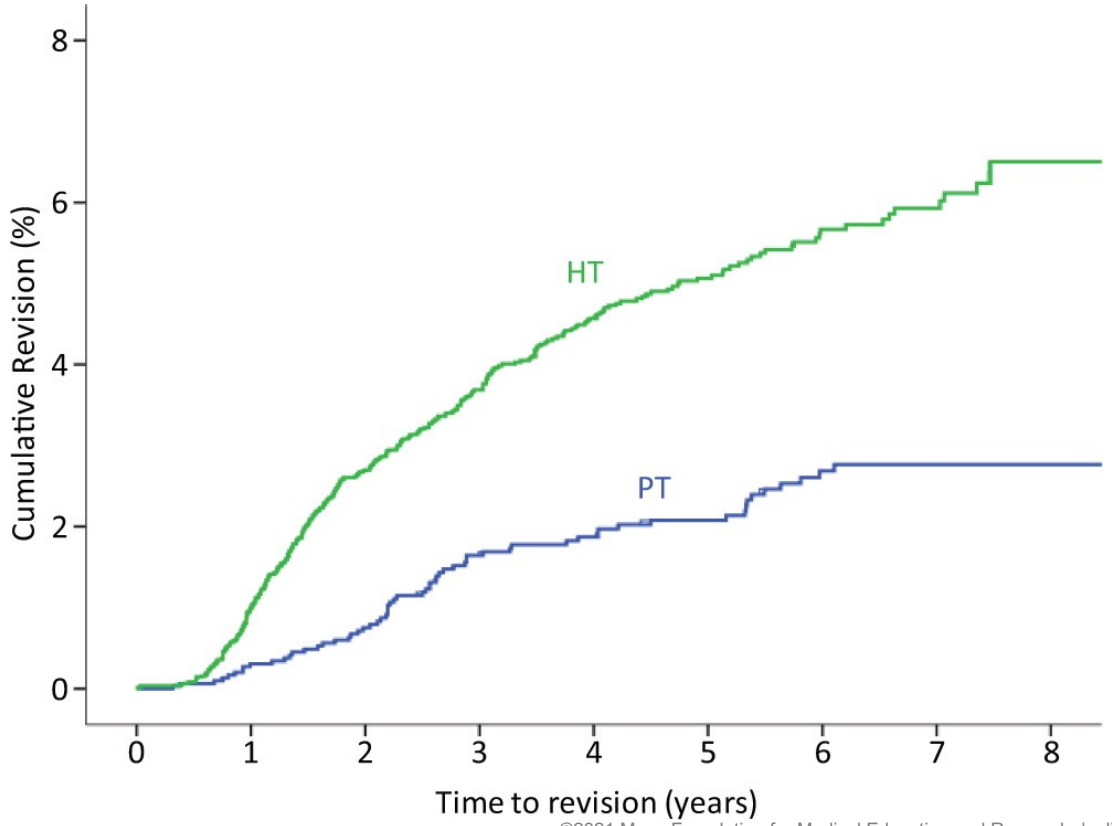
GRAFT TYPE

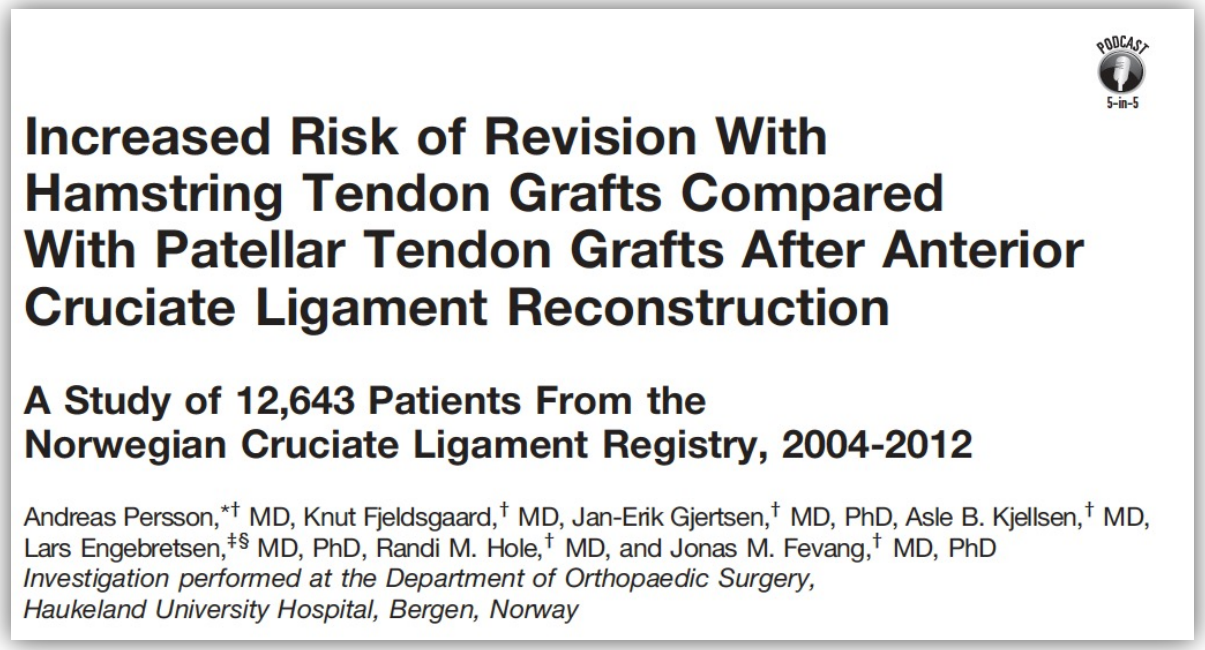
- Retrospective review Norwegian Registry
- Evaluated revision after 12,643 primary ACLRs
- 5 Year Revision Rate
  - Hamstring → 5.1%
  - BTB → 2.1%
- **HR 2.3** (95% CI 1.8-3.0) for hamstring vs patellar tendon grafts
  - Patients 15-19 y/o → **HR 4.0** (95% CI 3.1-5.2)

Increased Risk of Revision With Hamstring Tendon Grafts Compared With Patellar Tendon Grafts After Anterior Cruciate Ligament Reconstruction

A Study of 12,643 Patients From the Norwegian Cruciate Ligament Registry, 2004-2012

Andreas Persson,*† MD, Knut Fjeldsgaard,† MD, Jan-Erik Gjertsen,† MD, PhD, Asle B. Kjellsen,† MD, Lars Engebretsen,‡§ MD, PhD, Randi M. Hole,† MD, and Jonas M. Fevang,† MD, PhD
Investigation performed at the Department of Orthopaedic Surgery, Haukeland University Hospital, Bergen, Norway





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"We can only speculate what caused this increased risk of revision in the HT group"

PREDICTING RETEAR RISK

- Prospectively evaluated 56 athletes for 12 months
  - 3D gait lab Analysis performing DVJ
  - Postural stability assessment
- Predictive Factors
  - Trunk (OR 2.3)
    - **Increased single leg instability (Biodex)**
  - Knee (OR 3.5)
    - **Increased total frontal plane movement (Valgus)**
    - **Decreased knee flexion moment**
  - Hip (Most Predictive; OR 8.4)
    - Increased hip internal rotation moment (contralateral)
      - 78% Sensitive, 81% Specific
  - Limb Asymmetry (OR 3.3)

Biomechanical Measures During Landing and Postural Stability Predict Second Anterior Cruciate Ligament Injury After Anterior Cruciate Ligament Reconstruction and Return to Sport

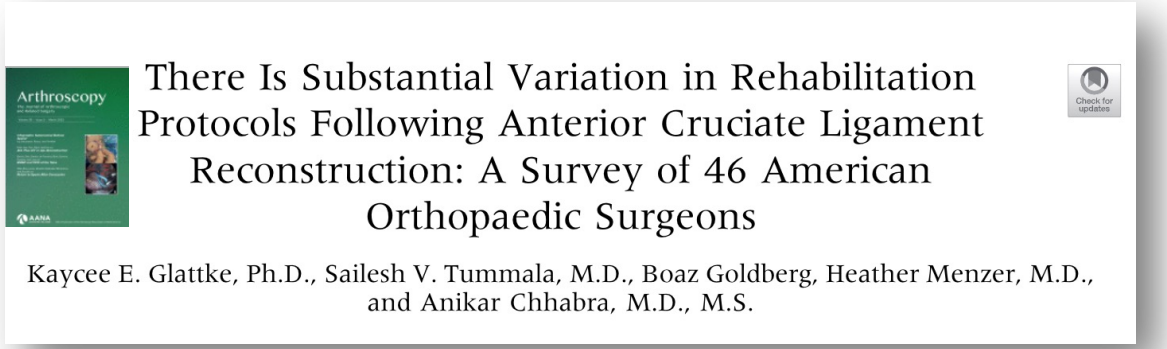
Mark V. Paterno,*†‡§‖¶ PT, MS, SCS, ATC, Laura C. Schmitt,†‡§# PT, PhD, Kevin R. Ford,†‡‖ PhD,

2D Peak frontal plane knee valgus (Θ=16.2°)

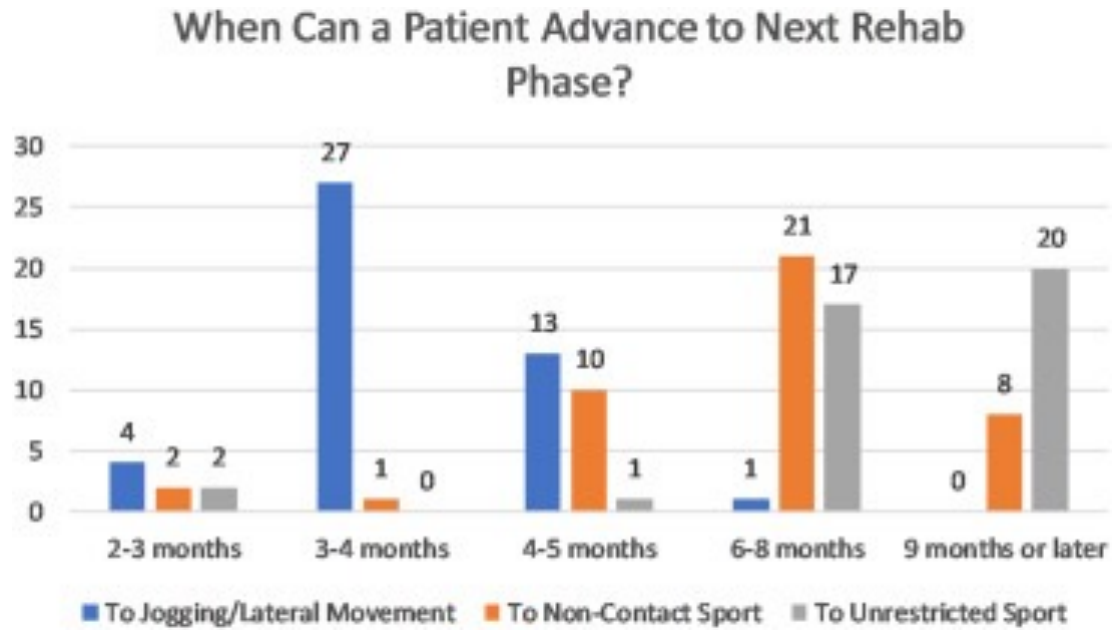
TABLE 2
Multivariable Model Odds Ratio Estimates

Variable	Odds Ratio	95% Confidence Interval
Uninvolved hip rotation net moment impulse (initial 10% of landing)	8.4	2.1, 33.3
2-dimensional frontal plane knee motion during landing	3.5	1.3, 9.9
Side-to-side difference in sagittal plane knee moment at initial contact	3.3	1.2, 8.8
Postural stability on involved limb	2.3	1.1, 4.7

WHY DOES THE 6-MONTH TIME POINT MATTER?



- Most providers recommend RTP >9 months after surgery
- **The 6–9 month time point is critical in targeting rehabilitation**

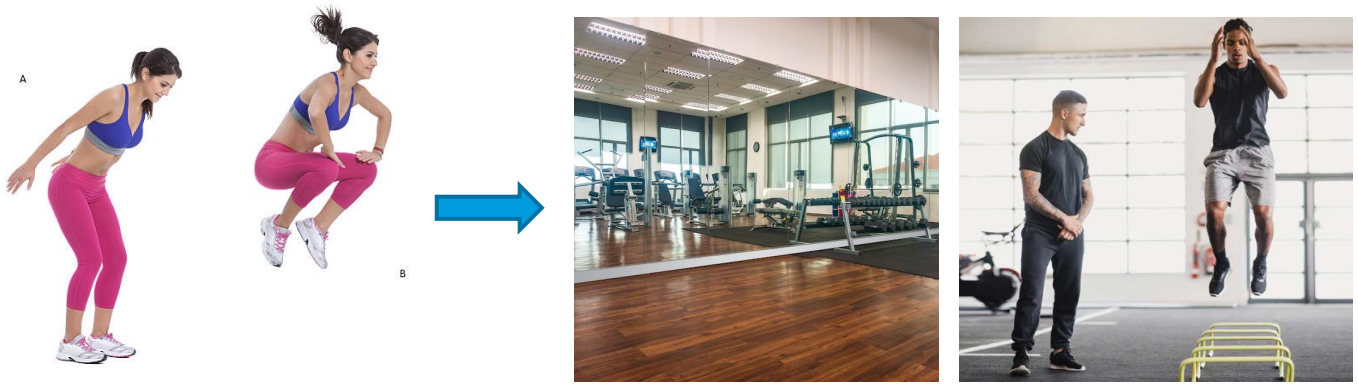


ADDRESSING PATHOLOGIC MOVEMENT PATTERNS

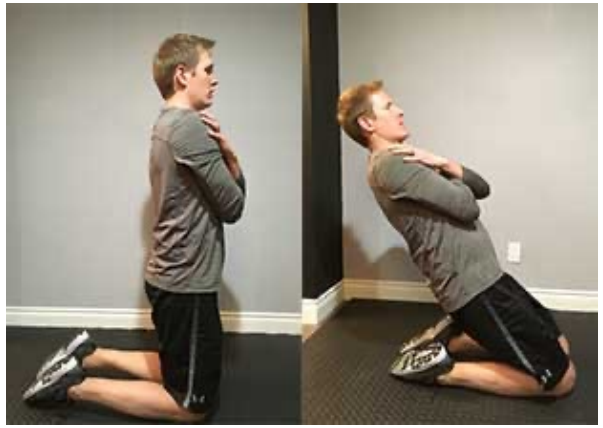
Knee Valgus → Train Proper Landing Technique

Train Gluteal Musculature (Abductors)

Knee Extension → Strengthen Extensor Mechanism



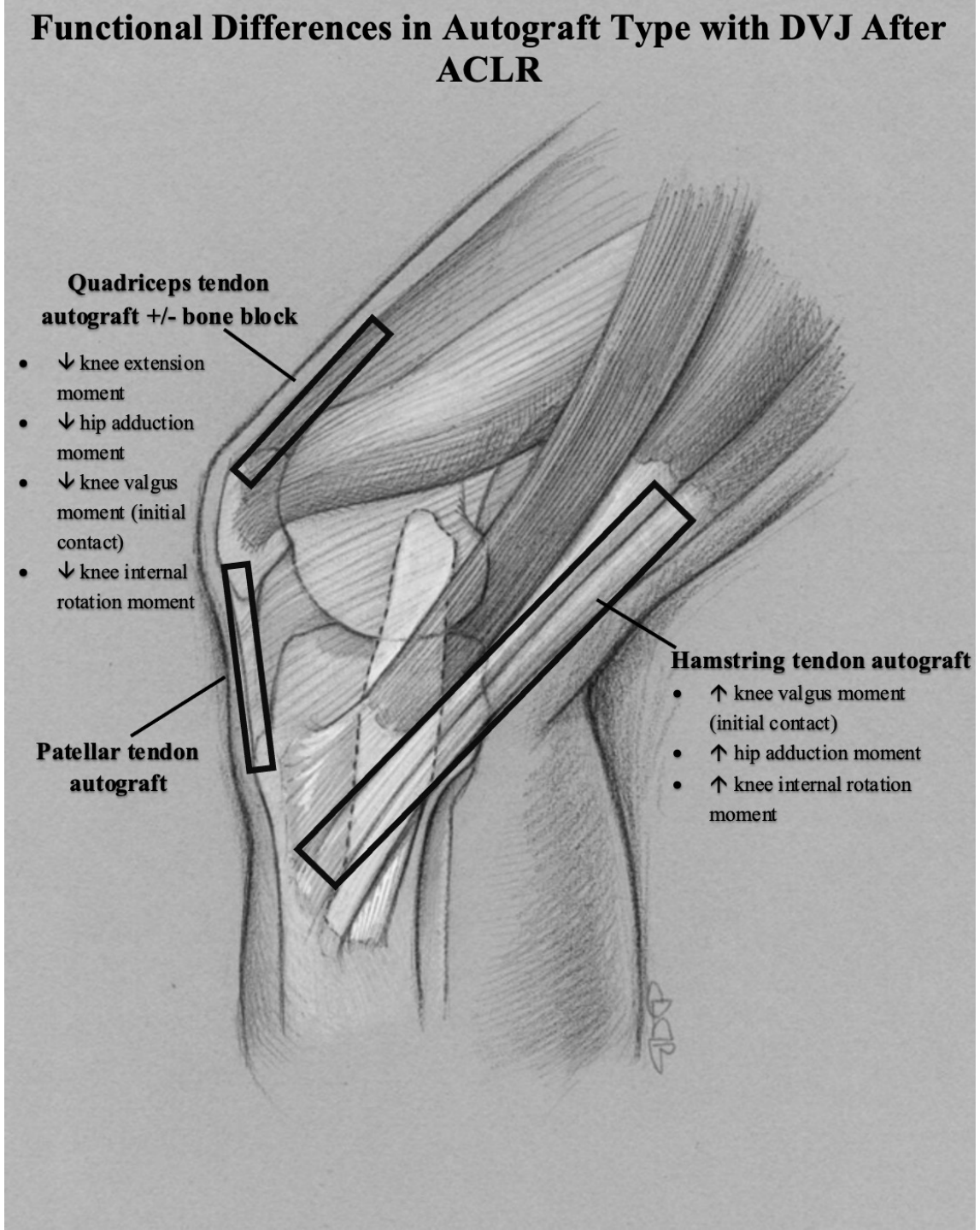
Plyometric exercise with Biomechanical Feedback



Extensor Mechanism Strengthening

Hewett TE. *N Am J Sports Phys Ther*. 2010;5(4):234-251.; ForeverFitScience

CONCLUSIONS



CONCLUSIONS

- *Hamstrings Autograft* associated with **hip adduction and knee valgus** at 6 months after ACLR during DVJ
  - Dynamic knee valgus associated with increased risk of ACL retear in prior literature
- *Quadriceps Autografts* associated with **decreased extensor mechanism moments** at 6 months after ACLR during DVJ

CONCLUSIONS

- **"Robbing Peter to Pay Paul"**
  - Each autograft has a *unique postoperative biomechanical profile* of altered movement after ACLR
  - Surgeons should be *thoughtful* about graft choice based on expected biomechanical deficits
  - Deficits should be targeted early in rehabilitation

LIMITATIONS

- Nonrandomized patient cohort
- No long-term clinical performance data on retear rates
- Two surgeon series at a tertiary hospital in Southwest United States may limit generalizability

ACKNOWLEDGMENTS

- Phoenix Children’s Hospital Biomechanics Lab

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THANK YOU

