ACL Revision
"My Bag of Tricks"

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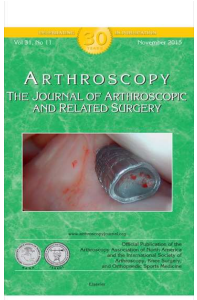
Disclosures

- Committees: AAOS Sports Medicine/Arthroscopy Chairman, AOSSM Publication, AANA Health Policy, ISAKOS Knee/Joint Preservation, ACL Study Group Membership Committee
- Editorial Board: Arthroscopy Journal, American Journal of Orthopedics, Current Orthopedic Practice
- Research Support: Arthrex, RTI, Zimmer, Cartiheal
- Consultant: Arthrex, RTI, Vericel, Conmed, Moximed, Ceterix
- Advisory Boards: Vericel, RTI, Neotis
- Special thanks to Aaron Krych , Al Getgood, and Tim Spalding

Missour-A patients may NOT be same as your patients…



My Bag of Tricks

Neuromuscular testing

Bone grafting

Slope decreasing tibial osteotomy

Lateral Tibia X-ray

Mechanical Axis View

CT 3D recon

Biplanar HTO

Quadriceps autograft

Meniscal Transplant

Lateral extra-articular tenodesis

Meniscus Root repair

Evidence Based Humility

- 4th ACL tear since Junior HS

Get it right the FIRST time

- FAILURE defined in many ways
  - Graft re-rupture
    - Age <16→ 26%
    - Age >18→9% *(Astor, Cohen et al KSSTA 2017)*
  - Recurrent instability with intact graft
  - Failure to RTP (30-40%)
  - Meniscus loss and cartilage injury (37-80%)

Pre-operative Counseling

- Manage unrealistic expectations
  - Negatively influence PROs
    - 80-90% expect same level of activity, no/minimal pain, no/minimal instability, no/slightly increased OA risk

Patient expectations of primary and revision anterior cruciate ligament reconstruction

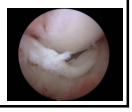
Matthias J. Feucht · Matthias Cotic · Tim Saier · Philipp Minzlaff · Johannes E. Plath · Andreas B. Imhoff · Stefan Hinterwimmer

Pre-operative Counseling

- Revision outcomes are worse than primary ACL
  - Graft failure
  - Higher rate of irreparable meniscus tears and chondral lesions
    - Lower Lysholm and IKDC
  - Higher rate of need for further surgery

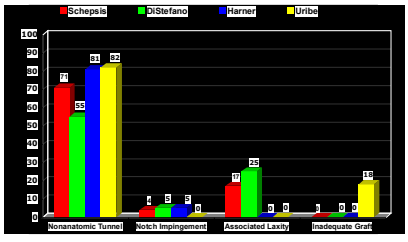
Outcome of Revision Anterior Cruciate Ligament Reconstruction: A Systematic Review

Rick W. Wright, MD, Corey S. Gill, MD, Ling Chen, PhD, Robert H. Brophy, MD, Matthew J. Matava, MD, Matthew V. Smith, MD, and Nathan A. Mall, MD



History

- Cause failure multifactorial

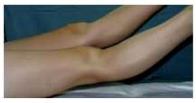


History

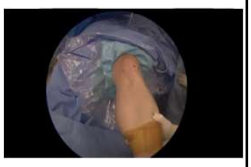
- Look for RED FLAGS
  - Why did it fail? What can I do differently?
    - Graft choice (i.e. allograft in young athlete)
    - Prior 'functional' meniscectomy
    - Early RTP (4 mos) without functional assessment
- 'Near normal' or 'never normal'
  - Traumatic vs. insidious
  - Episodic instability, painful effusion, or both

Physical Exam/EUA

- Hyperlaxity
  - Symmetric or asymmetric

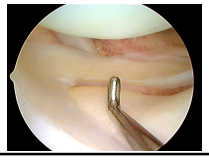


- Explosive pivot shift
  - IIIB, III pivot

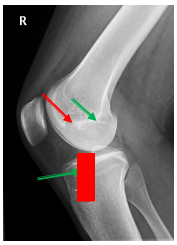


Physical Exam/EUA

- Secondary stabilizers
  - EUA/Stress views
    - Arthroscopic "drive through"



Lateral X-ray



Lateral X-ray

Alignment Views

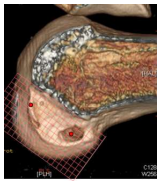
- Mechanical Axis View
  - Varus/valgus
    - Symmetry
- Standing Tibial Lateral
  - Increased tibial slope
  - Anterior tibial translation

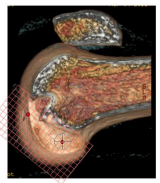
CT 2D

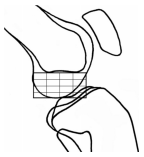
- Tunnel diameter/orientation
  - Tunnel enlargement >14mm → TWO STAGE

CT 3D reconstruction

- Tunnel position
  - Perfect
  - Way out



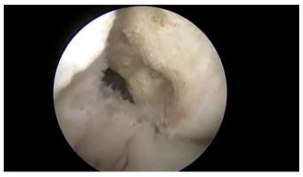


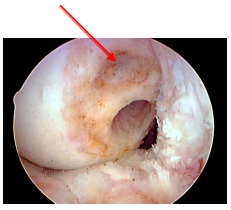


Bernard and Hertel Grid

CT 3D reconstruction

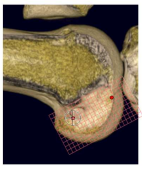
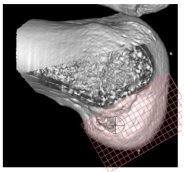
- 1 stage revision





CT 3D reconstruction

- Tunnel overlap
  - TWO STAGE
  - SINGLE STAGE USING TECHNICAL TRICKS
    - (i.e. larger bone blocks, blocking screws)

Graft Choice

- Autograft is 2.8X less likely to rupture
  - Superior KOOS, IKDC, and 2 yr Marx activity

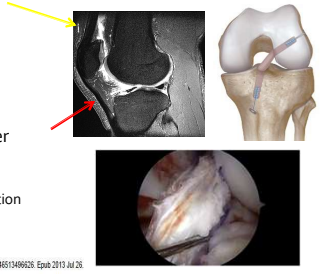
Effect of Graft Choice on the Outcome of Revision Anterior Cruciate Ligament Reconstruction in the Multicenter ACL Revision Study (MARS) Cohort

The MARS Group*†
Investigation performed at the Department of Orthopaedic Surgery, Washington University School of Medicine at Barnes-Jewish Hospital, St Louis, Missouri, USA

The American Journal of Sports Medicine, Vol. 42, No. 10
DOI: 10.1177/0363546514549005

The Quadriceps Advantage

- Readily available
- Low Morbidity
- Predictably large Diameter
- Bone or no bone
  - Suspensory or aperture fixation

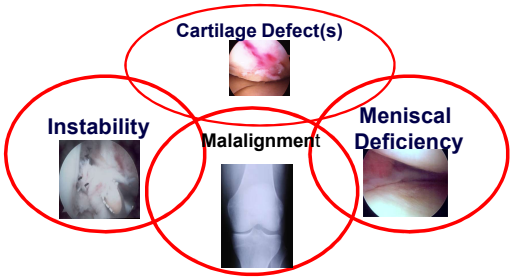


Am J Sports Med. 2013 Oct;41(10):2392-9. doi: 10.1177/0363546513499626. Epub 2013 Jul 26.

Anatomic and morphological evaluation of the quadriceps tendon using 3-dimensional magnetic resonance imaging reconstruction: applications for anterior cruciate ligament autograft choice and procurement.

Xerogeanes JW*, Mitchell PM, Karasev PA, Kolesov IA, Romine SE

Concomitant Procedures



JOINT IS AN ORGAN!! MUST RECOGNIZE AND TREAT ALL CO-MORBIDITIES

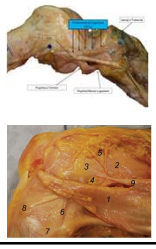
Recognize and treat anterolateral rotatory instability

- ACL is NOT the only structure controlling rotation

The Role of the Anterolateral Structures and the ACL in Controlling Laxity of the Intact and ACL-Deficient Knee

The Effect of Medial Versus Lateral Meniscectomy on the Stability of the Anterior Cruciate Ligament-Deficient Knee

The Influence of Meniscal and Anterolateral Capsular Injury on Knee Laxity in Patients With Anterior Cruciate Ligament Injuries



Lateral extra-articular tenodesis

Am J Sports Med. 2017 Nov;45(13):3089-3097. doi: 10.1177/0363546517724422. Epub 2017 Sep 12.

Anterolateral Tenodesis or Anterolateral Ligament Complex Reconstruction: Effect of Flexion Angle at Graft Fixation When Combined With ACL Reconstruction.

Inderhaug E[1], Stephen JM[2,3], Williams A[2], Amis AA[2,4].

Lateral Extra-articular Tenodesis Reduces Rotational Laxity When Combined With Anterior Cruciate Ligament Reconstruction: A Systematic Review of the Literature

Combined intra-articular and extra-articular ACL reconstruction reduced the pivot shift

Revision ACL reconstruction: influence of a lateral tenodesis

Failure rate: IA = 15%, IA + EA = 7%

Negative pivot shift: IA = 63%, IA + EA = 80%

No difference in IKDC scores

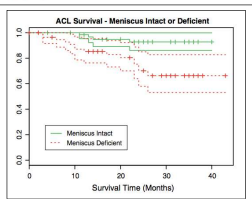
Preserve or Replace the Meniscus

Knee Surg Sports Traumatol Arthrosc
DOI 10.1007/s00167-014-3277-x

KNEE

Meniscal integrity predicts laxity of anterior cruciate ligament reconstruction

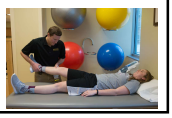
Curtis Robb · Peter Kempshall · Alan Getgood · Hayley Standell · Andrew Spowson · Peter Thompson · Tim Spalding



Preserve or replace the meniscus

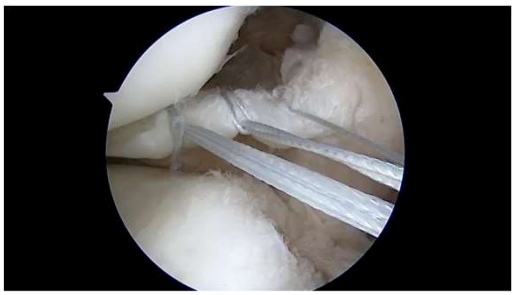
- Medial meniscus
  - Posterior horn is secondary restraint to anterior tibial translation
    - **'Brakestop'** mechanism

- Lateral meniscus
  - May stabilize tibial internal rotation and help modulate the pivot shift
    - Root tears associated with high grade pivot shift

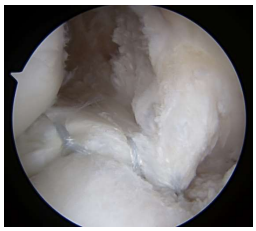


High index of suspicion for root/ramp tears

Transosseous root fixation



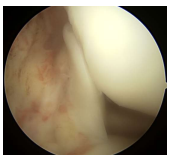
Final Construct

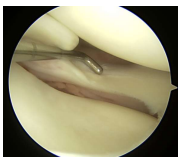


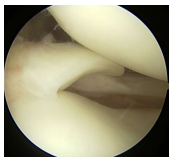
SL2

Repair complex tear patterns

- 17 M s/p prior failed ACL and complex LM tear with extrusion



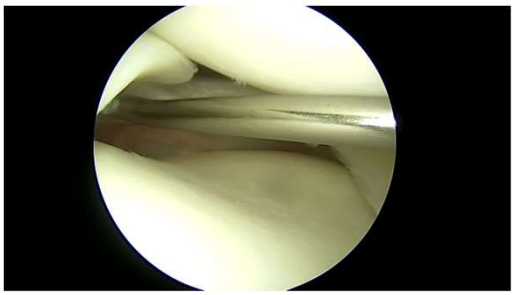




Slide 30

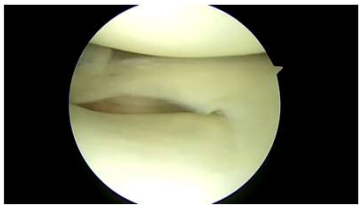
SSL2 Noah Kratzer
Sherman, Seth L., 4/22/2018

Case Example



SSL1

Case Example



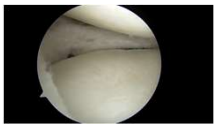
Case Example

Slide 32

SSL1 Sherman, Seth L., 4/22/2018

Meniscus Deficiency

- Medial meniscal deficiency is a MAJOR CAUSE OF FAILURE OF PRIMARY ACL RECONSTRUCTION

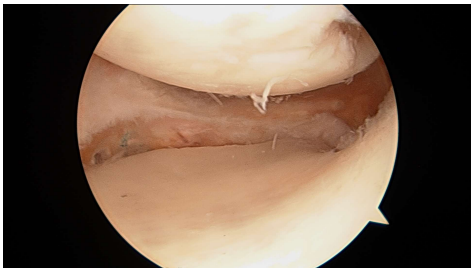


- Combined Revision ACL/ medial MAT
  - III B Lachman, high grade pivot
  - Indication : INSTABILITY and NOT pain

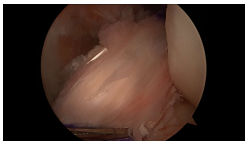
Case Example

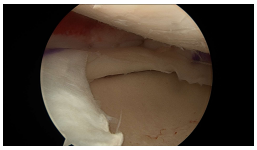
- 21 yo M 2 prior failed ACL allograft reconstructions
  - IIIB Lachman, III pivot, hyperlaxity
  - Good prior tunnel position
  - Normal alignment including tibial slope
  - MM deficiency
  - Cartilage intact

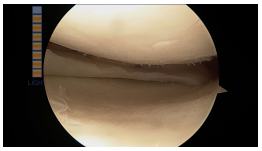
Case Example



Revision Quad Autograft + Medial Meniscus Transplant, Lateral Tenodesis







Case Example

12 wk s/p re-revision ACL Quad Using Autograft and MM Tx

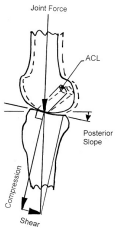
Case Example: 9 mos s/p revision ACL Quad Autograft + MMTx

Recognize and Correct Varus Malalignment

- Excessive varus malalignment means greater in-situ graft forces
  - *Hinckel et al Orthopedics 2016*
- HTO reduces biomechanical stress
  - Improves clinical outcome
    - Technical Tip: Do NOT increase tibial slope

Recognize and Consider Correcting Tibial Slope in Salvage

- Increases shear strain on ACL
- An increase in 4° slope with 200N axial load results in increase of 3mm anterior translation



Effects of Increasing Tibial Slope on the Biomechanics of the Knee

J. Robert Giffin, MD, Tracy M. Vogrin, MS, Thore Zantop, Savio L-Y. Woo, PhD, DSc, and Christopher D. Harner,* MD
From the Musculoskeletal Research Center, Department of Orthopaedic Surgery, University of Pittsburgh, Pittsburgh, Pennsylvania

Clinical Relevance of Tibial Slope

Posterior Tibial Slope and Further Anterior Cruciate Ligament Injuries in the Anterior Cruciate Ligament–Reconstructed Patient

Justin M. Webb,* MBBS, FRACS, Lucy J. Salmon,*† PhD, Etienne Leclerc,* MD, Leo A. Pinczewski,* MBBS, FRACS, and Justin P. Roe,* MBBS, FRACS
Investigation performed at the North Sydney Orthopaedic and Sports Medicine Centre, Sydney, New South Wales, Australia

Slope >12 degrees
59% rupture same or contralateral side
Risk increased 5x

20-Year Outcomes of Anterior Cruciate Ligament Reconstruction With Hamstring Tendon Autograft

AJSM 2017

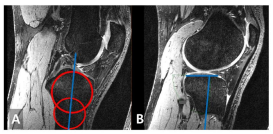
The Catastrophic Effect of Age and Posterior Tibial Slope

Lucy J. Salmon,*† PhD, Emma Heath,* MPhty, Hawar Akseer,* MBChB, MSc, FRCS(Tr&Orth), Justin P. Roe,* MBBS, FRACS, James Linklater,‡ FRANZCR, and Leo A. Pinczewski,* MBBS, FRACS
Investigation performed at North Sydney Orthopaedic & Sports Medicine, Wollstonecraft, Australia

179 of 200 ACL's with 20yr follow up (89%)
Post tibial slope > 12 degrees = 65%!

Recognize and Consider Correcting Tibial Slope in Salvage Situations

- Measure on X-ray or MRI
  - >12° considered abnormal



Tibial Deflexion Osteotomy

- Re-revision ACL reconstruction

Knee Surg Sports Traumatol Arthrosc (2015) 23:2846–2852
DOI 10.1007/s00167-015-3758-6

KNEE

Tibial slope correction combined with second revision ACL produces good knee stability and prevents graft rupture

David Dejour[2] · Mo Saffarini[2] · Guillaume Demey[1] · Laurent Baverel[1]

Proximal Tibial Anterior Closing Wedge Osteotomy in Repeat Revision of Anterior Cruciate Ligament Reconstruction

Bertrand Sonnery-Cottet,*† MD, Stefan Mogos,† MD, Mathieu Thaunat,† MD, Pooler Archbold,† MD, Jean-Marie Fayard,† MD, Benjamin Freychet,† MD, Julien Clechet,† MD, and Pierre Chambat,† MD
Investigation performed at the Centre Orthopédique Santy and Hôpital Privé Jean Mermoz, Lyon, France

Case Example

- Problem List: 22 yo M
  - Failed ACL recon
  - Prior subtotal medial meniscectomy
  - Asymmetric varus malalignment
  - Staged HTO followed by Quad Autograft ACL +Medial Meniscus Transplant

Case Example

- Problem List: 45F firefighter with multiple failed ACL and repeat medial meniscectomy
  - Functional instability with huge cystic tunnels
  - Medial pain
    - Varus, MM deficiency, increased tibial slope

Biplanar Osteotomy

- Valgus producing and slope decreasing osteotomy

Case Example

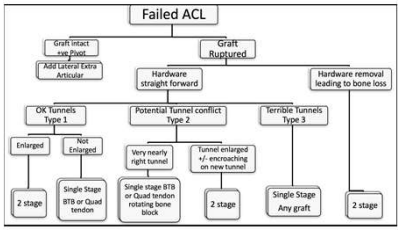
- 22 yo M with 3x ACL failure bilaterally
  - Increased tibial slope
  - Failed ACL with tunnel widening
  - Medial meniscus deficiency

Case Example

Case Example

One Stage vs. Two Stage

- Have an algorithm



Consider Single Stage Revision

- Clear reason for failure
  - High demand-> traumatic, good graft choice, good tunnel position without widening
  - Poor graft choice or poor original tunnel position
  - Early return likely cause of failure

Single Stage Checklist

- No significant malalignment
- No or minimal tunnel widening
  - Prior hardware removable or irrelevant
- Repairable meniscus or meniscus sufficient
- Minimal or asymptomatic chondral defect(s)
- Treatable concomitant corner injury
- Treatable hyperlaxity

Surgical Technique

- Leave hardware if not in the way
- Scope first, drill BEFORE taking graft if unsure
- Flexible Reamer AM portal
  - Suspensory fixation with soft tissue graft
- Outside-in with retrocutter

Two Stage Revision

- Stiff knee requiring arthrolysis
- Tunnel enlargement requiring bone grafting
- Complex decision making
  - Malalignment
  - Suspected meniscus deficiency
  - Chondral defects requiring treatment

Staging Arthroscopy

- Correlate H&P, imaging, EUA, and intra-operative findings
  - GREAT OPPORTUNITY TO THINK!
  - Problem List
    - Arthrofibrosis
    - Tunnel bone grafting
    - Extra-articular alignment (i.e. HTO)
  - Return for ACL , meniscus , cartilage

Bone Grafting

- No consensus

Orthopedics. 2016 May 1;39(3):e456-64. doi: 10.3928/01477447-20160324-01. Epub 2016 Apr 5.

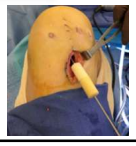
Two-Stage Revision Anterior Cruciate Ligament Reconstruction.

Erickson BJ, Cvetanovich G, Waliullah K, Khair M, Smith P, Bach B Jr, Sherman S.

Two-Stage Revision Anterior Cruciate Ligament Reconstruction Using Allograft Bone Dowels

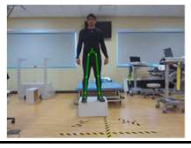
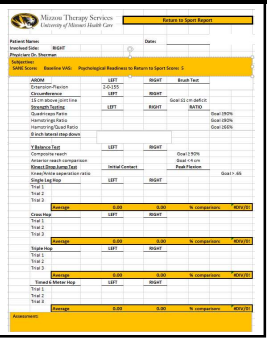
Kadir Buyukdogan, M.D., Michael S. Laidlaw, M.D., and Mark D. Miller, M.D.





Mizzou RTP Functional Evaluation

- Independent PT eval
  - Separate appointment
- Pass/Fail
  - Explanations
  - Tailored Home Program

Mizzou Therapy Services
University of Missouri Health Care

Return to Sport Report

Patient Names
Involved Side: RIGHT
Physician Dr. Sherman
Subjective:
SANE Score: Baseline VAS: Psychological Readiness to Return to Sport Score: S

AROM	LEFT	RIGHT	Brush Test	
Extension-Flexion	0-0-155			
Circumference	LEFT	RIGHT		
15 cm above joint line			Goal ≤1 cm deficit	
Strength Testing	LEFT	RIGHT	RATIO	
Hamstrings				Goal ≥90%
Hamstrings Peak				Goal ≥90%
Hamstring/Quad Ratio				Goal ≥66%
8 inch lateral step down				
Y Balance Test	LEFT	RIGHT		
Composite reach			Goal ≥ 90%	
Anterior reach comparison			Goal < 4 cm	
Kinesit Drop Jump Test	Initial Contact		Peak Flexion	
Knee/Ankle separation ratio				Goal > .65
Single Leg Hop	LEFT	RIGHT		
Trial 1				
Trial 2				
Trial 3				
Average	0.00	0.00	% comparison	#DIV/0!
Cross Hop	LEFT	RIGHT		
Trial 1				
Trial 2				
Trial 3				
Average	0.00	0.00	% comparison	#DIV/0!
Triple Hop	LEFT	RIGHT		
Trial 1				
Trial 2				
Trial 3				
Average	0.00	0.00	% comparison	#DIV/0!
Timed 6 Meter Hop	LEFT	RIGHT		
Trial 1				
Trial 2				
Trial 3				
Average	0.00	0.00	% comparison	#DIV/0!

Assessment:

AIM To Correct All Problems

- Alignment
- Instability
- Meniscus
- Tunnels
- Chondral
- Anterolateral rotation
- Physiotherapy

Otherwise doomed to failure again

Thanks!

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