

Chang Gung Memorial Hospital

ACL injury and management

專科醫師考題解答

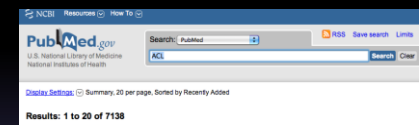
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2011-06-18



KNEE RECONSTRUCTION & SPORTS MEDICINE

Analyzing results

- Difficult
- PubMed



- ACL: 7138
- ACL Reconstruction: 3044
- ACL Graft: 1495
- ACL Meta-Analysis: 43

ACL Injury

- Incidence: 35 in 10,000 people
- 80% Sports related
- 70% noncontact
- Landing
- Twisting



- Hoshino, AJSM 2007
- OKU 10

Mechanism

- Audible pop or tearing sensation
- Knee swelling
- Definite injury time
- Video analysis
 - foot flat
 - knee abduction
 - hip flexion



- Boden, AJSM 2009
- OKU 8


Risk factors

- Participation of high risk activities
- Generalized ligamentous laxity
- Higher body mass index
- Size of ACL
- Dimension of intercondylar notch
- Female
- Cyclic hormonal levels: 1st half of menstrual cycle
- Genetics

- OKU 9
- OKU 10
- Hewett, AJSM 2007
- Posthumus, AJSM 2009

ACL function

- Primary restraint against
 - anterior loads
 - internal rotation torques
- Prevent pivot shift of the knee



- OKU 10
- Yasuda, AJSM 2011

Associated injuries

- ACL + LM tear: **acute** ACL disruption
- ACL + MM tear: **chronic** ACL deficient knee
- Cartilage and meniscus tears increase over time
- Recurrent instabilities are associated with development of arthritis

- Granan, AJSM 2009
 - Taylor, Knee Surg Sports Traumatol Arthrosc 2009
 - OCL 10

Physical Examination

- Anterior drawer test
- Lachman test
- Pivot shift test
- KT-1000 arthrometer



Review of Evidence – ACL

Table 3. Comparison of 3 Clinical Examination Techniques for Diagnosing Anterior Cruciate Ligament Tears*

Study (Reference)	Lachman Test		Anterior Drawer Test		Pivot Test	
	Sensitivity	Specificity	Sensitivity	Specificity	Sensitivity	Specificity
Borer and Ackard (14)	0.62	0.90	0.56	0.92	0.31	0.97
Handberg et al. (43)	0.74	NA	0.58	NA	0.29	NA
Davies et al. (44)	0.99	NA	0.95	NA	0.70	NA
Imeson et al. (42)	0.87	NA	0.33	NA		
Liu et al. (43)	0.95	NA	0.61	NA		
Stamatakis (55)	1.0					
Torg et al. (71)	0.95	NA	0.61	NA	0.71	NA
Kulp and Reynolds (75)	0.89	NA	0.41	0.95	0.78	0.98
Hoyes et al. (76)		NA	0.56	NA	0.89	NA
Lee et al. (79)	0.89	NA	0.78	1.0		
Hightsham et al. (81)			0.58	0.23		
Summary Statistic (95% CI)	0.87 (0.76-0.96)	0.91 (0.89-0.96)	0.48 (0.32-0.59)	0.87 (0.83-0.91)	0.61 (0.40-0.82)	0.97 (0.91-0.99)

(Jackson JL, et al.)

- Lachman Test Sens 87% Spec 93%
- Pivot Shift Test Sens 61% Spec 97%
- Anterior Draw Sens 48% Spec 87%

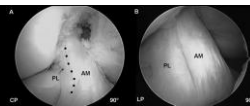
Image

- X-ray
- MRI



- OKU 8

ACL anatomy



- Nonparallel collagen fibers bound into multiple fascicles and surrounded by synovium
- 2 functional bundles
 - AM
 - PL
- 2-bundle anatomy is already present during fetal development

- Dimitschek, CORR 1978
 - Girgis, CORR 1975
 - Ferretti, Arthroscopy 2007

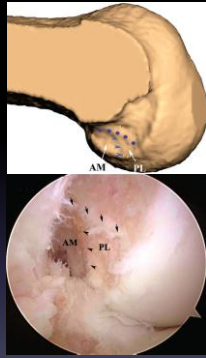
ACL femoral insertion



- From the over-the-top position downward along the cartilage contour
- 18 mm long (± 2 mm)
- 9 mm wide (± 1 mm)

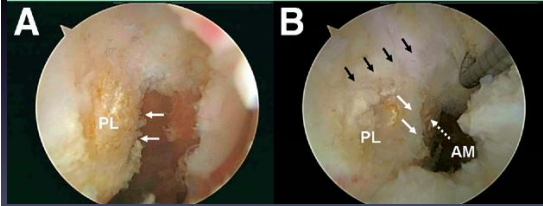
Femoral landmark

- "Resident's ridge" by W. Clancy
- The femoral insertion of both bundles is distal to the lateral intercondylar ridge and separated by bifurcate ridge

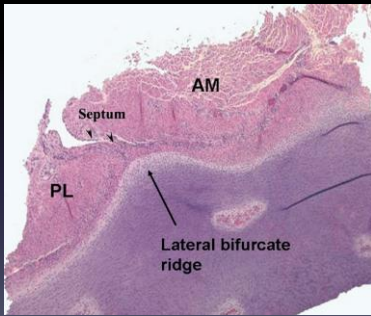


- Ferretti, Arthroscopy 2007

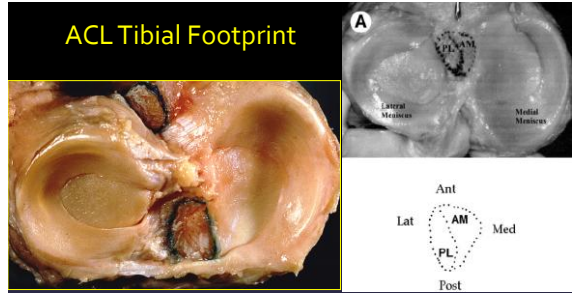
ACL Femoral footprint



Histology view



ACL Tibial Footprint

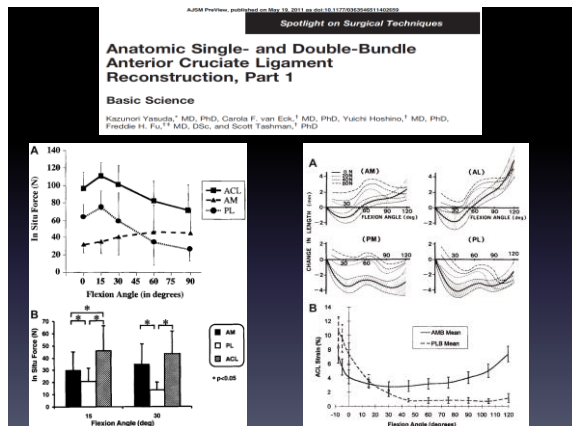


- Medial to the anterior horn of the lateral meniscus
- 17 mm long (± 2 mm)
- 9 mm wide (± 2 mm)

Function of AM and PL bundle

- **AM bundle**
 - anterior-posterior stability
 - tight throughout the range of motion of the knee
 - maximum tension between 45-60 degrees
- **PL bundle**
 - rotational stability
 - tight primarily in extension
- Individual contribution varies with knee flexion angle

- Ferretti, Arthroscopy 2007
 - Chhabra, JBJS Am 2006
 - Guilleli, JOR 2004
 - Yasuda, AJSM 2011

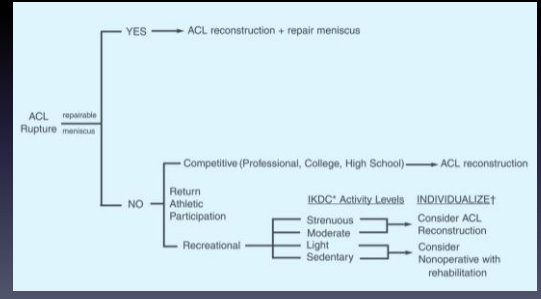


OKU 7: Indications for ACL reconstruction

2000
IKDC
KNEE FORMS

Level	The IKDC four types of activity
I	jumping, cutting, and pivoting sports
II	heavy manual labor, side-to-side sports
III	light manual work, noncutting sports
IV	sedentary activity without sports

OKU 8: ACL reconstruction decision making



OKU 10: Indications for ACL reconstruction

- Young
- High demand athletics
- Symptoms of instability

Non-Operative Treatment

- Successful candidates
 - < 7 mm in KT-1000
 - < 50 hours of cutting, pivoting and jumping sports per year
- High failure rate in patients
 - > 7 mm in KT-1000
 - > 200 hours of cutting sports

ACL treatments

- Ruptured ACL will not heal spontaneously with nonoperative management
- Nonaugmented primary ACL repair (ie, just suturing the torn ends of the ligament) has also been proven to be unsuccessful
- Primary repair: high failure rates, reason unknown, may due to poor blood supply and inhibitory factors of synovial fluid

• Reconstruction

- Barrack, CORR 1990
 - Gronqvist, JBJS Am 1996
 - Taylor, AJSM 2009

Why ACL reconstruction?

- Decrease secondary meniscal injury and articular cartilage injury
- Reduce the risk of developing degenerative joint disease
- In vivo animal study: continuous instability of the knee causes degenerative joint disease

- Conry, AJSM 1999
 - Warner Arthroscopy 1998
 - Weeds, Knee 2001
 - Adinolfi

ACL Graft choices

- Indications
- Single bundle / double bundle
- Anatomy
- **Graft**
 - autograft
 - BPTB
 - Hamstring
 - Achilles
 - Tibialis A/P
 - allograft

- Clinical Sports Medicine by Johnson & Mair 1st Ed 2006
OKU 10

BPTB



Advantages	Disadvantages
Rigid fixation	Anterior knee pain
Bone-to-bone healing	Extensor mechanism change
Initial graft strength	Loss of quadriceps strength
Durable stability	Patellar fracture

Hamstring



Advantages	Disadvantages
Highest strength and stiffness	Fixation
Like native ACL	Tunnel widening
Less morbidity	Unpredictable size
Spare physis	Hamstring weak

Quadriceps



Advantages	Disadvantages
Similar strength	Decrease of up to 20% of Q- strength
Less knee pain	Extensor mechanism change
Kneeling	Risk of entering the suprapatellar pouch
For revision surgery	Patellar fracture

Graft strength

TABLE 24-4 BIOMECHANICAL GRAFT PROPERTIES

Graft	Ultimate Strength (N)	Stiffness (N/mm)	Cross-sectional area (mm ²)
Intact ACL	2160	242	44
BTB	2376	812	35
Quadruple hamstring	4108	776	53
Quad tendon	2352	463	62
Anterior tibialis	3412	344	38
Posterior tibialis	3391	302	48

ACL, anterior cruciate ligament; BTB, bone-patellar tendon-bone; N, Newtons.

(Adapted from Miller SL, Gladstone JN. Graft selection in anterior cruciate ligament reconstruction. Orthop Clin North Am 2002;33:675-683.)

2001

Patellar Versus Hamstring Tendons in Anterior Cruciate Ligament Reconstruction: A Meta-analysis

Michael Yunes, M.D., John C. Richmond, M.D., Eric A. Engels, M.D., M.P.H., and Leo A. Piaczewski, F.R.A.C.S.

2003

Arthroscopic anterior cruciate ligament reconstruction: a metaanalysis comparing patellar tendon and hamstring tendon autografts.

Freedman SB, D'Amato MJ, Nestoff DD, Saxe A, Basch BB Jr. Sports Medicine Section, Department of Orthopaedic Surgery, Rush Medical College, Rush-Presbyterian-St. Luke's Medical Center, Chicago, Illinois, USA.

2004

Anterior cruciate ligament reconstruction autograft choice: bone-tendon-bone versus hamstring: does it really matter? A systematic review.

Sandhu SC, Smith JC, Freedman SB, Matthews LG, Shaha SS, Daniels TR Jr. Vanderbilt University Medical Center, Nashville, Tennessee, USA. scs@vanderbilt.edu

2005

Reconstruction of the anterior cruciate ligament: meta-analysis of patellar tendon versus hamstring tendon autograft.

Goldblatt JP, Fitzammons SE, Balk E, Richmond JC. Department of Orthopaedics, University of Rochester, Rochester, New York 14642, USA. jgoldblatt@yahoo.com

Meta-Analysis Conclusions



Hamstring

- Lower rate of anterior knee pain
- Less extension loss
- Less need for manipulation



Patellar tendon

- Better stability
- Lower graft failure
- More likely to have normal Lachman, KT-1000, Pivot

Contralateral Autograft

Am J Sports Med, 2008 Sep-Oct;28(5):851-8.
Primary anterior cruciate ligament reconstruction using the contralateral autogenous patellar tendon.
 Shalbourne KD, Ulrich SE
 Methodist Sports Medicine Center, Indianapolis, Indiana, USA.

- Faster return to unrestricted sports
- 4.1months vs. 5.5 months
- Same stability as ipsilateral
- Better early strength
- **OKU8: Contralateral Graft: decreased morbidity on the reconstructed knee and faster patient recovery**

Contralateral Autograft

Am J Sports Med, 2007 Jan;35(1):85-93.
Donor site morbidity and return to the preinjury activity level after anterior cruciate ligament reconstruction using ipsilateral and contralateral patellar tendon autograft: a retrospective, nonrandomized study.
 Hettlerstein DS, Sattorian J, Sestini G, Parniani P
 ATOS Clinic, Center for Knee and Foot Surgery, Sport Surgery, Heidelberg, Germany.

- Similar ipsilateral results
- Donor site morbidity transfer to other knee
- Not statistically faster return to sports: 7.4 months vs. 7.8 months

Allograft indication

- Revision surgery
- Multiple ligament: PCL, PLC, collateral ligament
- Primary ACL reconstruction in the older patient
- Patient preference
 - cosmetics
 - decreased postoperative pain

Allografts



Advantages

- Quicker surgical techniques
- No morbidity associated with graft harvest
- Cosmetics

Disadvantages

- Small risk of viral transmission (1/1.6 million)
- Costs
- Slower graft incorporation
- Higher rate of graft failure



Achillis tendon
 \$ 1550
 NTD 150000



Semi-T / Gracillis
 \$ 1250
 NTD 90000



BPTB
 \$ 2500
 NTD 270000



Tibialis Anterior
 \$ 1500
 NTD 90000

Meta-analysis and systemic reviews Autograft vs. Allograft

Knee Surg Sports Traumatol Arthrosc, 2007 Jul;15(7):851-6. Epub 2007 Apr 17.
A meta-analysis of stability of autografts compared to allografts after anterior cruciate ligament reconstruction.
 Prodromos G, Jozsa B, Shi K.
 Illinois Sports Medicine and Orthopaedic Centers, Rush University Medical Center, 1720 N. Milwaukee, Glenview, IL 60025, USA, research@amoc.net

2007

Arthroscopy, 2008 Mar;24(3):292-4. Epub 2007 Nov-5.
A meta-analysis of patellar tendon autograft versus patellar tendon allograft in anterior cruciate ligament reconstruction.
 Kuyoh AJ, Jackson JD, Hoskin TL, Dahm DL.
 Department of Orthopedic Surgery, Mayo Clinic, Rochester, Minnesota 55905, USA.

2008

J Bone Joint Surg Am, 2009 Sep;91(9):2242-50.
A systematic meta-analysis of autograft versus allograft to ligament reconstruction with autograft compared with allograft.
 Cahley AL, Du.
 Department of Orthopaedics and Rehabilitation, Vanderbilt University Medical Center, Nashville, TN 37232, USA, james.cahley@vanderbilt.edu

2009

Graft choices consideration

- Patient dependent
- Lifestyle
- Sports activity
- Age
- Technique dependent
- Single / double bundle
- Pre-existing comorbidities
- Costs
- Availability
- Biocompatibility
- Safety
- Donor site morbidity

- Clinical Sports Medicine by Johnson & Mair 1st Ed.2006

OKU 7 - 10 about graft choice

- Variety of outcomes
- Some Higher percentages of failure in allograft group
- Unclear which graft is best
- Autograft choices do not consistently favor one over another
- 4-strand hamstring vs. PTBT: similar function outcome



Question: Which graft will he choose?

Patellar Autograft	1 (5%)		3 (45%)
Hamstring Autograft			
Allograft			10 (50%)

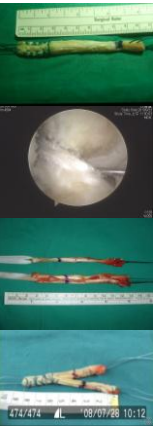
Total Votes: 20

History

- Open vs. Scopic
- First: 2 incision
- Early 1990s: 1-incision

Surgical Techniques

- Single-bundle
- Selective-bundle
- Double-bundle ACL



Single bundle vs. Double bundle

- **Lab data** suggested double bundle provides improved rotational stability
- **Patient outcome studies** have not shown a consistent improvement in outcomes between single and double bundle

- Markolf, JBJS Am 2008
 - Markolf, JBJS Am 2009
 - Lewis, AJSM 2008
 - Meredith, AJSM 2008

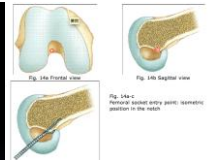
Contraindications for Double bundle reconstruction

- Tibial insertion site < 14 mm in diameter
- Open physes
- Severe bone bruising
- Narrow notch
- Multiple ligamentous injuries

- Shen, AJSM 2008

Isometry

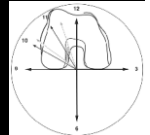
- Best isometry for the femoral tunnel
- Positive effects of isometric placement
- **However**, the native ACL is not isometric, but has a complex, nonuniform, double-bundle fiber anatomy



- Musahl, AJSM 2005

Clockface reference

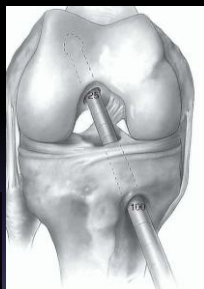
- 11:00 and 1:00
- Limitations
 - a. 2-dimensional structure
 - b. position varies with knee flexion
 - c. not universally employed



- Shen, AJSM 2008
 - Van Eck, Arthroscopy 2010

Femoral Tunnel Preparation

- Transtibial



Femoral Tunnel Preparation

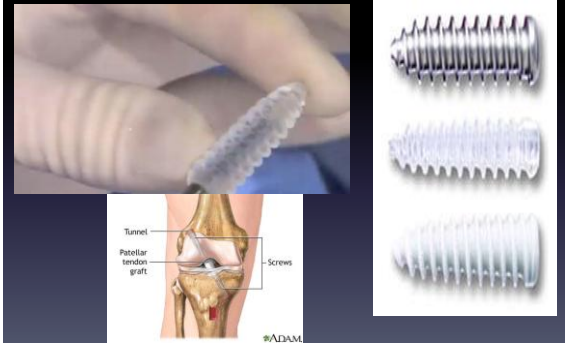
- Transportal



Graft Fixation



Interference screws



Cross-Pin / Transfix



Endobutton



Causes of ACL failure

- Nonanatomic tunnel placement
- Inadequate tensioning
- Insufficient fixation of the graft
- Premature return to sports
- Absent secondary stabilizers as a result of torn menisci
- Laxity of the medial or posterolateral structures

- Shen, AJSM 2008

Summary OKU 7

- Pediatrics or adolescents with open physis
- Acute primary repair or extra-articular reconstructions have little chance of lasting success and generally are not indicated
- Endoscopic techniques allow decreased morbidity and improved cosmesis but are technically demanding
- **Cross-pin fixation** methods provide initial strength and stiffness approaching that of BTB techniques
- "windshield wiper" effect
- **Patellar tendon grafts**: kneeling problems
- **Hamstring grafts**: tibial hardware complaints

Summary OKU 8

- Timing for reconstruction ACL
- ACL reconstruction: improved stability and decreased rate of meniscus reinjury after ACL reconstruction
- **Footprint:**
 - a. femoral tunnel: within 1 to 3 mm over the top position
 - b. tibial tunnel: behind the intercondylar roof in full extension
- **Artificial ligament:** inflammatory response and graft wear

Summary OKU 9

- **Poor signs:** significant radiographic osteoarthritis associated with meniscectomy, loss of extension, and greater residual laxity on Lachman testing after reconstruction
- **Double bundle:** no significant clinical differences despite improvements in stability test measures after early follow-up
- **Allograft:** Clinical outcome studies: no significant difference in knee function scores after allograft patella tendon reconstruction compared with historic cohorts (autograft patellar tendon)
- **Adolescent:** physal-sparing techniques are generally favored
- 11-14 y/o children: Quadrupled soft-tissue graft for tunnels traversing the tibia and femoral physis

Summary OKU 10

- Two bundles function at slightly different knee flexion angles
- **Femoral insertion:** both distal to the lateral intercondylar ridge and separated by the bifurcate ridge
 - AM bundle: taut in relative knee flexion
 - PL bundle: taut in knee extension
- Arthritis? Risk of cartilage lesion and meniscus tear increases over time, but not clear whether or not reconstruction alters this degenerative process
- **Transtibial femoral tunnel drilling** does not allow anatomic placement of the femoral tunnel
- **Transportal drilling** allows anatomic femoral insertion
- Low femoral tunnel and double bundle had similar rotational stability
- **Double vs. single bundle:** better rotational stability in Lab, no consistent improvement in outcomes
- Similar outcomes in 4-strand hamstrings and patellar tendon grafts

Thank you for your attention



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