Anterior Cruciate Ligament Reconstruction: Current Concepts Review

By: Dr. David Wismer
and Dr. Pradeep Alexander

June 22/01

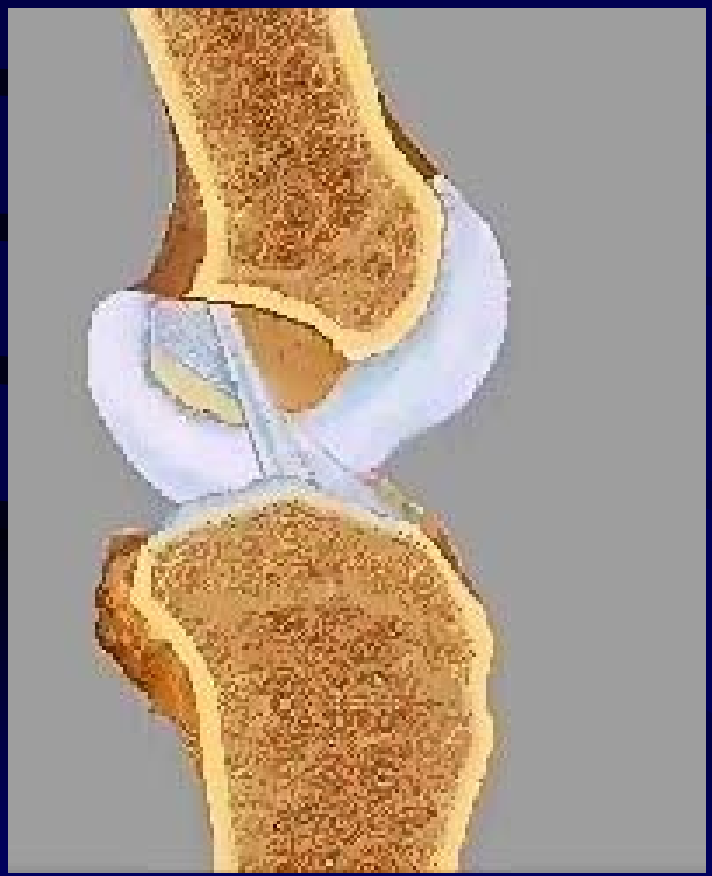
McMaster University

What is an ACL?

- stabilizing knee ligament
- Prevents abnormal anterior displacement and rotation of tibia on femur
- Two bands: small anteromedial band (tight in flexion) and large, bulky posterolateral portion (tight in flexion)
- Ultimate tensile load and stiffness is 2160±157N and 242±28N
- Normal ACL not isometric

Normal ACL function

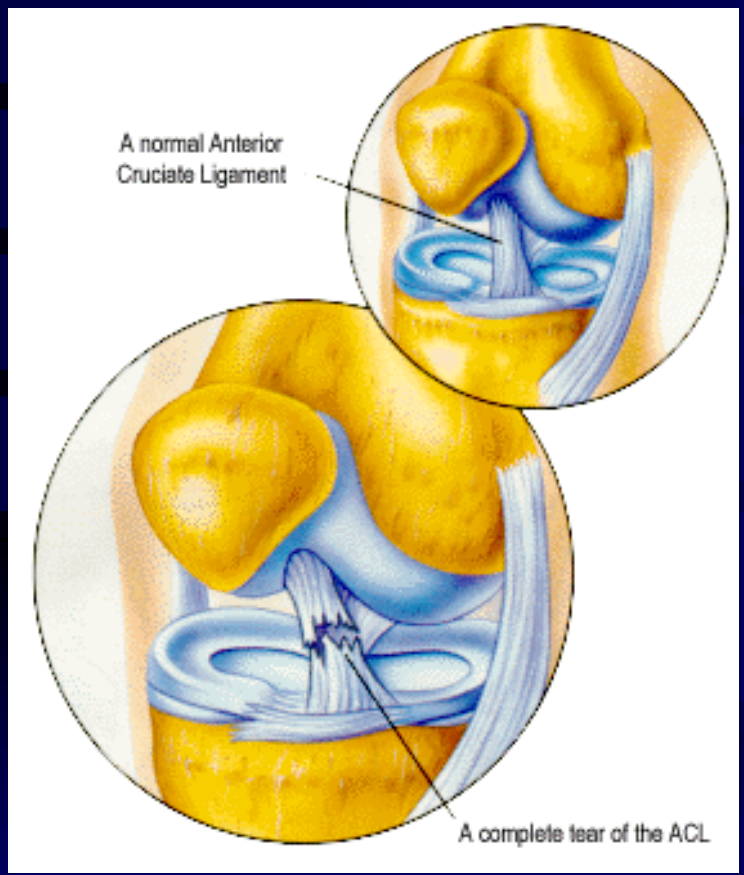
ACL tears



- risk of injury = 1 in 3000 Americans
- Football and basketball in younger patients
- skiing in older patients
- Substantial anterior tibial shear forces stress acl from quads contraction (esp 0 – 30 degrees contraction) (Sakane, ‘97)

McMaster University

ACL tears continued



- Typically torn in non-contact deceleration results in valgus twisting injury
- Athlete lands on leg and pivots in opposite direction

McMaster University

Significance of ACL tears

- Persistent joint instability and pain
- Structures at risk: Meniscus

  Chondral damage

  - cytokines, keratan sulphate ↑

- Acute traumatic hemarthrosis – 60 –70% incidence of ACL injury
- Associated meniscal injury – about 40 – 50%
- Associated bone bruise – 80%

McMaster University

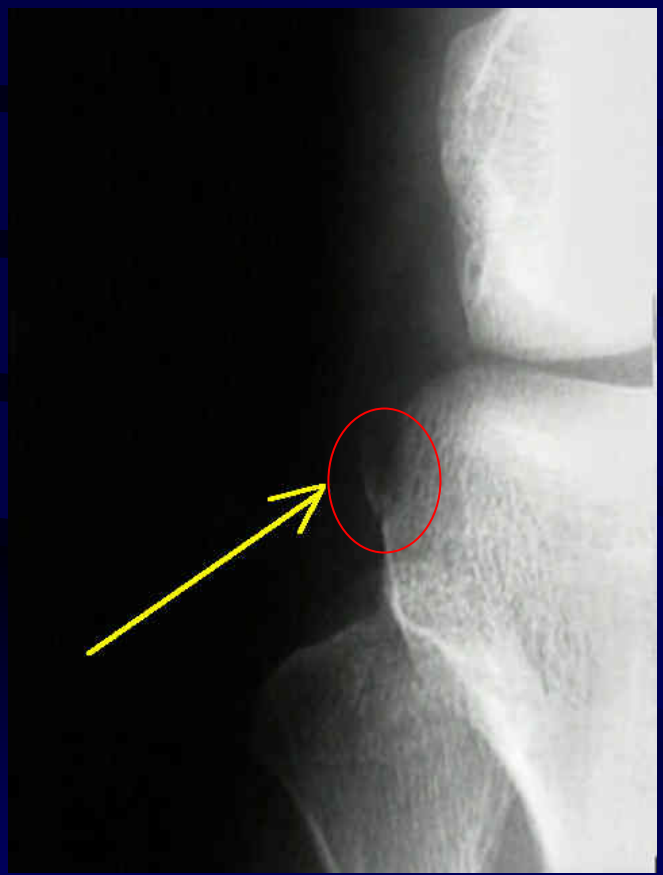
Significance of meniscal tear

- 40 – 50% are repairable
- Meniscal destruction leads to degenerative changes

Significance of bone bruise

- Posterolateral tibia ± anterolateral lateral femoral condyle
- 65% at 6 years shown to be significant
- Cartilage thinning and persistent subchondral marrow changes despite ACL reconstruction

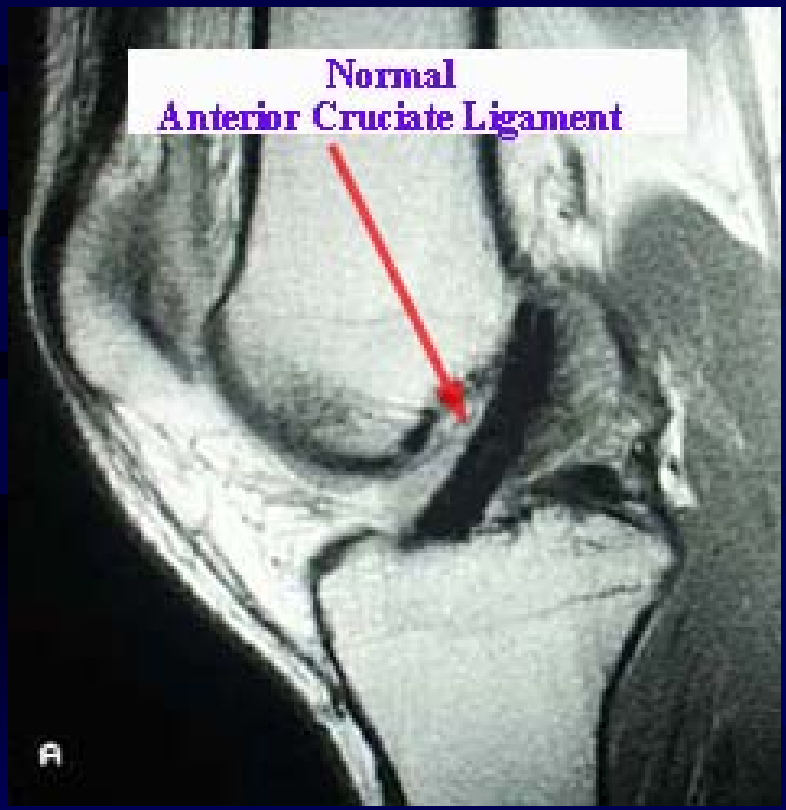
Plain films in acute ACL injuries

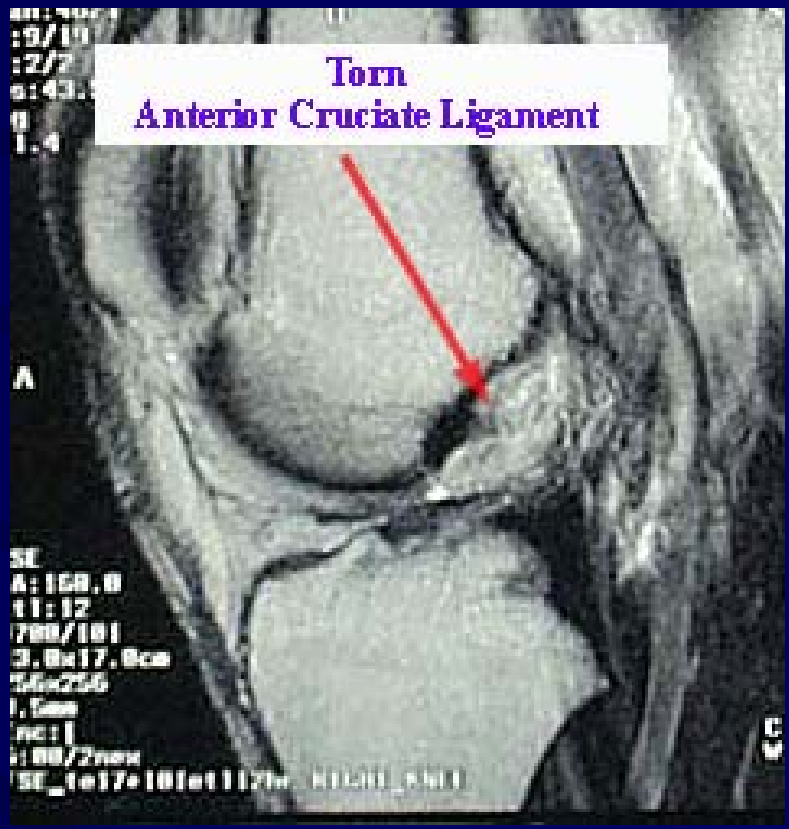


- Usually no finding
- Occasionally may find small avulsion fracture, lateral tibial condyle = *Segond fracture*

McMaster University

MRI in ACL tears





McMaster University

Pivot shift

- Positive Pivot

McMaster University

The Lachman test

Negative

Positive

McMaster University

Physical exam: Lachman vs. Anterior Drawer

- Lachman when done at 15 – 30 degrees of knee flexion – 85% specific for complete tear

- Anterior Drawer: 50% specific with a complete tear

Factors affecting progression of osteoarthritis

- Meniscal lesions
- Osteochondral lesions
- Concomitant ligamentous pathology

McMaster University

Natural history of ACL- deficient knee

- Untreated; anterior laxity, rotatory instability + meniscal tears
- Increase in X-ray changes of Deg. joint disease
- 1/3 with isolated ACL injuries show min. instability
- 2/3 will show gross instability
- Over 50% young patients will re-injure same knee after 1 year
- Over 1/3 of middle-aged patients will re-injure same knee after 1 year

McMaster University

Natural history continued

- Not fully understood
- Acute hemarthrosis of knee, may have:
  - occult lesions
  - osteochondral fractures
  - subcortical fractures
  - transcortical fractures

McMaster University

Treatment options – OA and ACL deficiency

- Disease progressive, no cure – temporizing
- Analgesics, anti-inflammatories, PT, bracing, modification of activities
- Bracing: prevents instability at low loads, relieves arthritic pain, esp. medial compartment (Lindenfeld, 1997), (Matsuno, 1997)
- ACL reconstruction

McMaster University

Non-operative treatment

- No good evidence that brace wear decreases rate of re-injury
- Older patients with isolated ACL injury who moderate their activity find non-operative treatment satisfactory in majority of cases (literature – 80%)

Indications for surgery – factors to consider

- Degree of ACL injury
- Presence of associated ligamentous, chondral and meniscal conditions
- Age/activity level/occupation
- Sports participation
- Patient compliance with post-op rehab

McMaster University

Timing of surgery

- Read the soft tissues
- Captured knee
- Creation of stiff knee – worst
- Pitfalls of ACL surgery

- FIRST attempt = best attempt; revision surgery outcomes 50 – 70% good - excellent

McMaster University

Types of ACL grafts

AUTOGRAFT

- bone-patellar tendon-bone
- Quadrupled semitendinosus/ gracilis tendon
- Bone quadriceps tendon

ALLOGRAFT

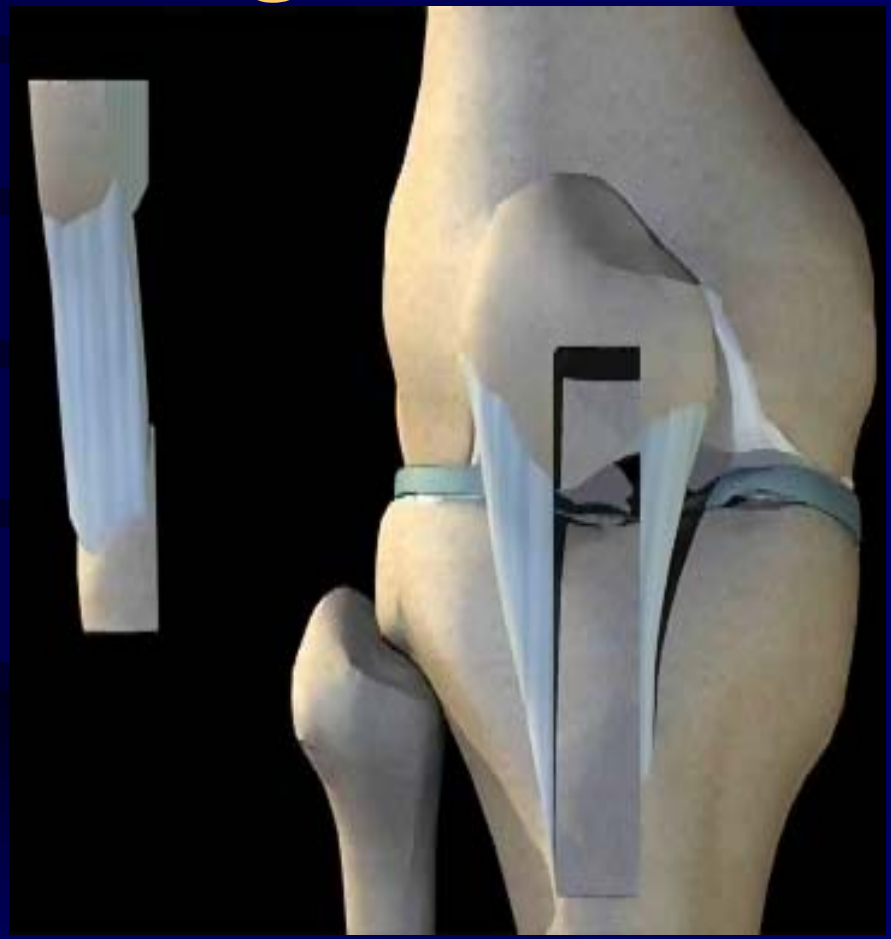
- Achilles tendon
- Bone-patellar tendon-bone
- Hamstring tendons

McMaster University

Patellar Bone-Tendon-Bone Graft

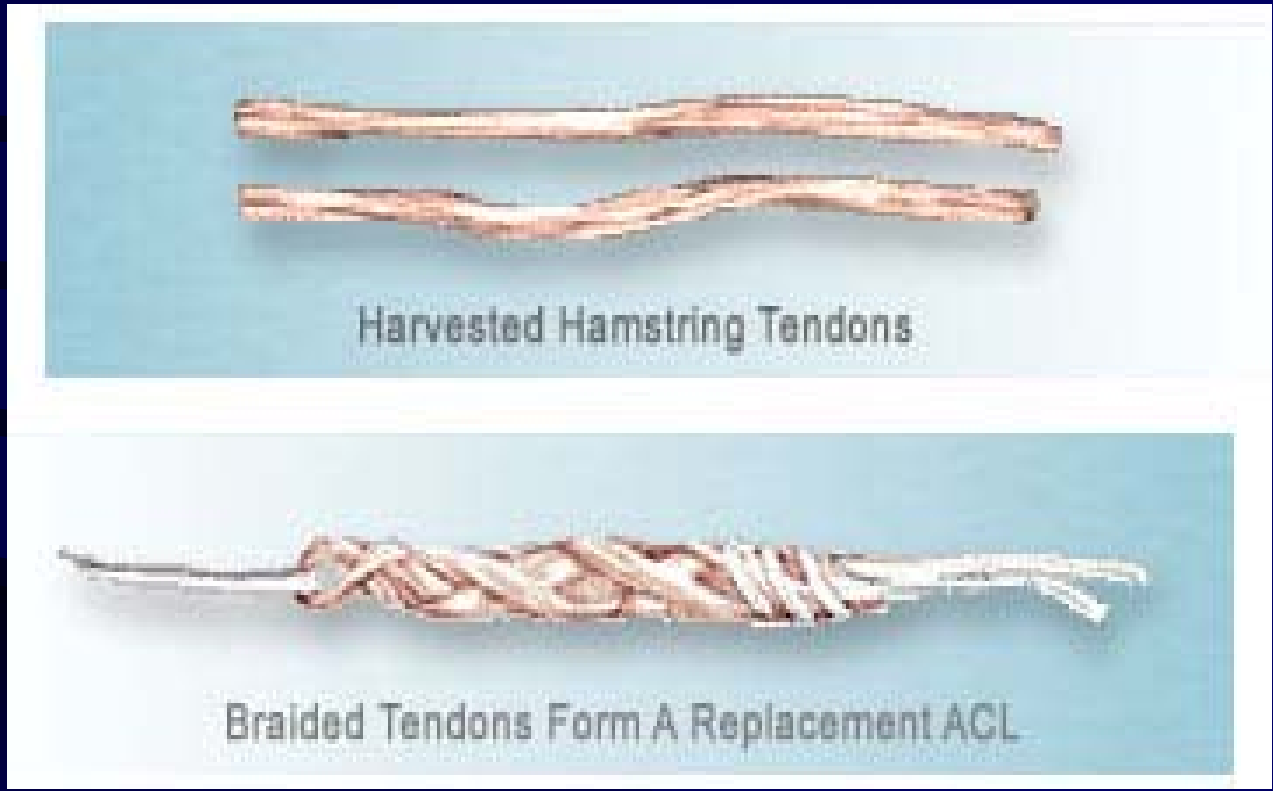
McMaster University

BTB graft continued



McMaster University

Hamstring tendon graft



McMaster University

Ultimate tensile load of intact Human ACL and a few common replacement ACL grafts

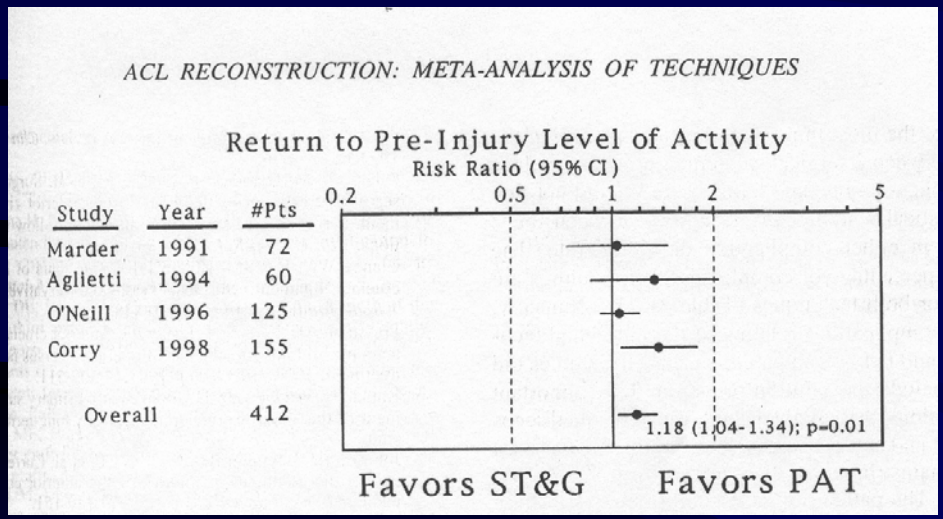
Graft type	Ultimate tensile load
Intact ACL	2160±154
Bone-patellar tendon-bone	2376 ±151
Single-strand semitendinosus	1216±50
Quadruple hamstring	4108±200
Quadriceps tendon (10mm)	2352±495

Meta-analysis of Patellar vs. Hamstring tendons in ACL reconstruction

- Controlled trials with minimum 2 year follow-up
- Evaluated; return to pre-injury level of activity, KT testing, Lachman scores, pivot shift scores, ROM, complications, failures
- 4 studies fulfilled inclusion criteria
- B-T-B showed a >20% chance return to pre-injury activity level versus hamstring, (p value = 0.01)

Yunes, M. et al "Patellar Versus Hamstring Tendons in ACL reconstruction; A Meta-analysis" Arthroscopy Vol. 17, No. 3 (March) 2001; pp248-257

Meta-analysis continued



- Relative risks and 95% confidence intervals shown
- BPTB patients are stat. Significantly more likely to return to return to pre-injury level of activity

McMaster University

Meta-analysis continued

TABLE 3. *PAT Versus ST&G: Relative Risks for Each Outcome*

Positive Outcome	O'Neill et al.[13]	Aglietti et al.[12]	Marder et al.[14]	Corry et al.[20]	Pooled Risk Ratio; *P* Value	Absolute % of PAT Patients With Outcome	Absolute % of ST&G Patients With Outcome
Return to preinjury activity level	1.05 (0.92-1.20)	1.33 (0.86-2.07)	1.03 (0.73-1.46)	1.37 (1.05-1.78)	1.18 (1.04-1.34); 0.01	75	64
Adverse Outcomes							
KT Max Manual > 3 mm	0.61 (0.24-1.51)	0.70 (0.44-1.11)	—	—	0.63 (0.44-1.02); 0.06	27	40
KT 20 lbs > 3 mm	—	0.78 (0.48-1.26)	0.63 (0.11-3.55)	0.35 (0.15-0.82)	0.57 (0.37-0.87); 0.009	17	29
Lachman > 1	1.41 (0.40-4.93)	—	0.68 (0.24-1.93)	0.21 (0.01-4.25)	0.81 (0.38-1.72); 0.59	7	8
Pivot Shift > 0	—	0.78 (0.33-1.82)	0.69 (0.31-1.51)	0.48 (0.21-1.13)	0.63 (0.39-1.01); 0.05	16	25
Pivot Shift > 1	—	0.33 (0.01-7.87)	0.47 (0.13-1.75)	1.04 (0.02-51.62)	0.48 (0.15-1.51); 0.21	2	5
ROM loss extension ≥ 1°	2.38 (0.12-48.53)	15.00 (2.11-106.49)	1.38 (0.75-2.54)	0.52 (0.10-2.75)	*	—	—
ROM loss flexion ≥ 1°	1.88 (0.42-8.46)	1.00 (0.36-2.75)	1.18 (0.82-1.70)	1.04 (0.07-16.30)	1.20 (0.84-1.72); 0.31	14	12
Complications	1.18 (0.39-3.52)	3.00 (0.13-70.83)	1.10 (0.41-2.96)	0.81 (0.31-2.06)	1.04 (0.59-1.83); 0.89	12	12
Failures	0.47 (0.07-3.22)	0.33 (0.01-7.87)	0.95 (0.06-14.55)	0.78 (0.18-3.37)	0.63 (0.23-1.73); 0.37	3	4

* As explained in the results section, we were unable to pool these results because of significant heterogeneity.

McMaster University

Rehabilitation in ACL injury

- Goals ROM
- Graft weakest at 6 – 12 weeks
- Ligamentization at 24 weeks
- Maturation 1 – 3 years
- Closed chain quad exercises: 4 – 8 months
- Open chain for hamstring

McMaster University

Rehab continued

- Rehab depends on: graft selection
  meniscal repair
  chondral debridement
- Micro-fracturing
- Brace hamstring for 6 weeks

Femoral notchplasty/roofplasty

- Create clearance for graft when knee is in extension
- Prospective, randomized study 100 pts found no beneficial short-term effect of performing a notchplasty (M.Cohen, 1998)
- Minimizing it – reduced post-op bleeding, pain, swelling and notch regrowth

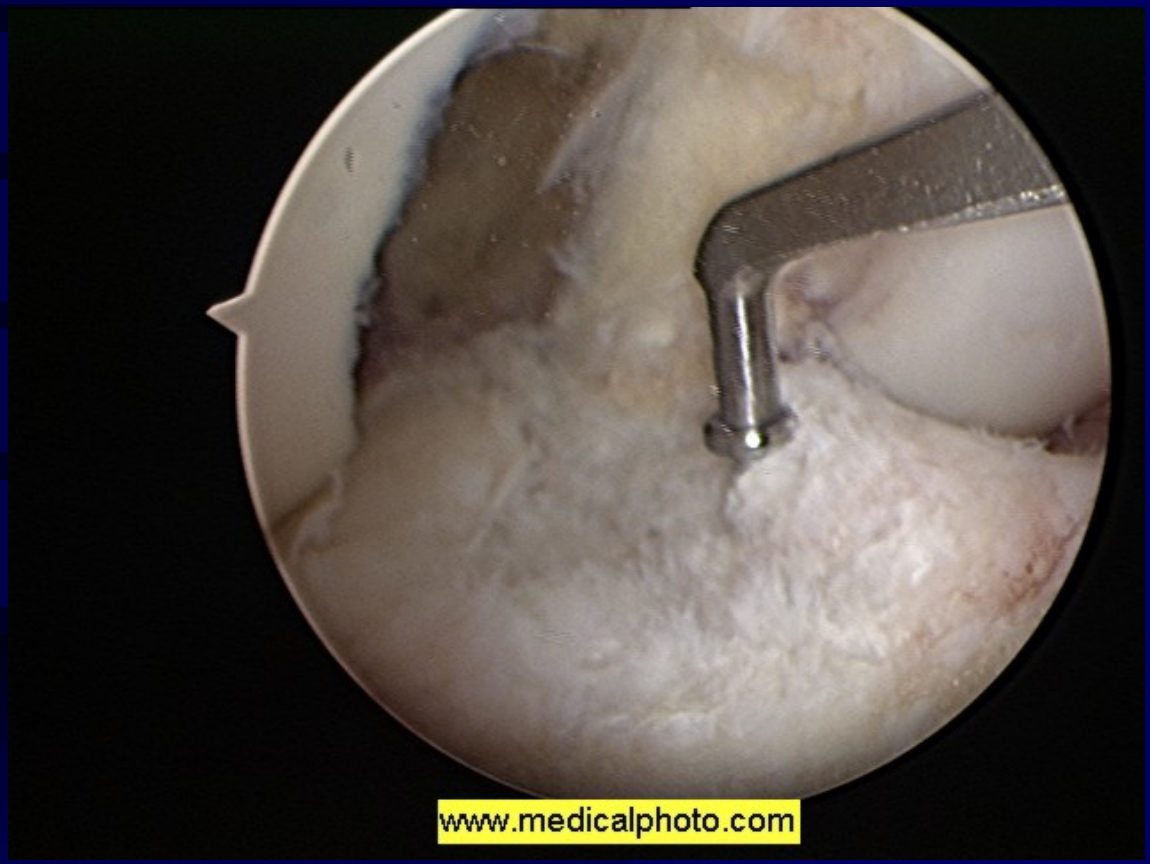
McMaster University

Drilling femoral and tibial tunnels

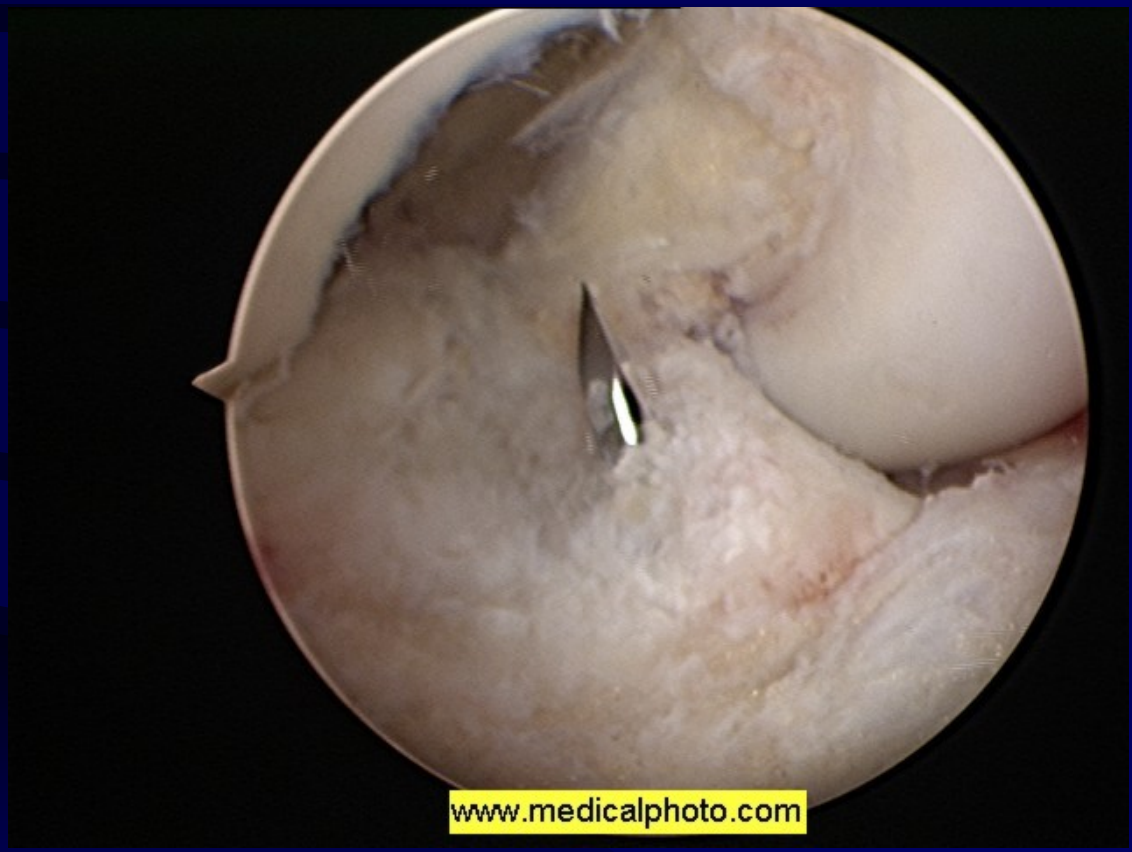
- Tunnel placement CRITICAL
- tibial tunnel 7mm ant PCL
- Femoral tunnel 1-2mm ant to femoral cortex
- post placed tibial tunnels, good outcomes (Harner et al, 1994)
- Ideal graft position still unknown

McMaster University

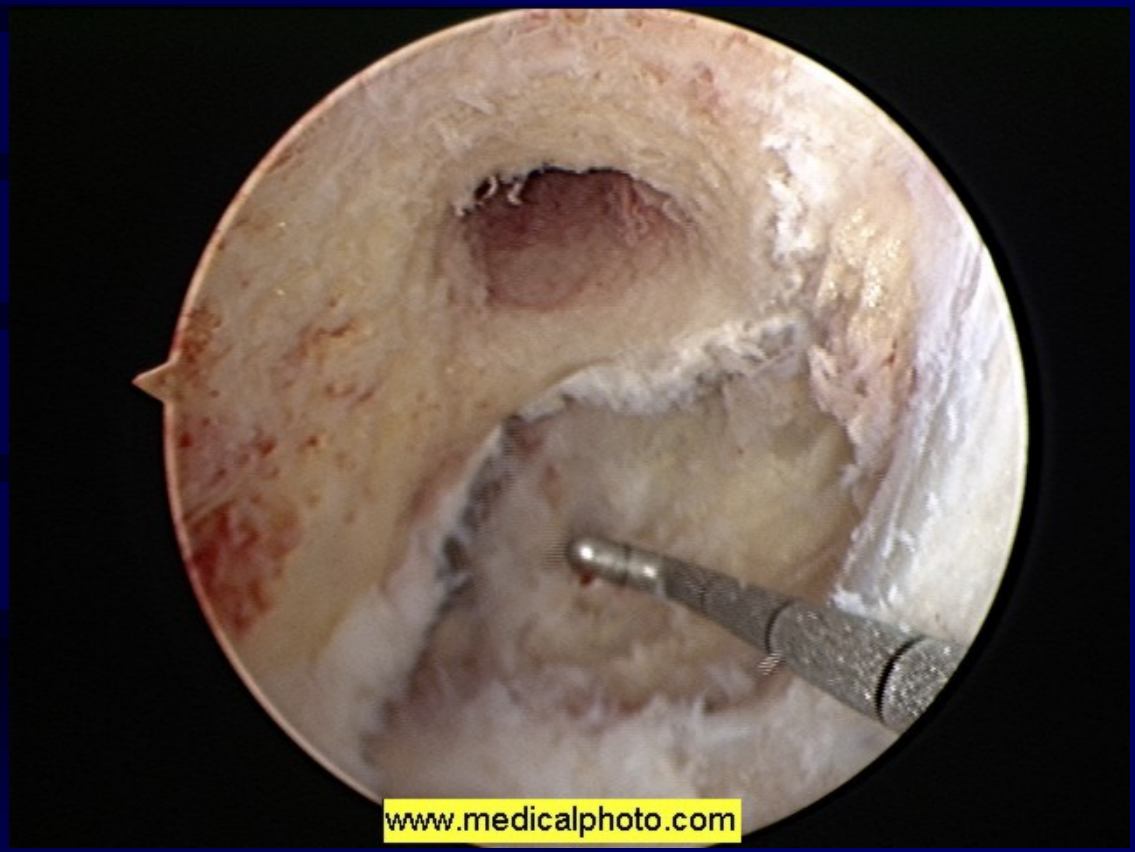
Tibial drill guide



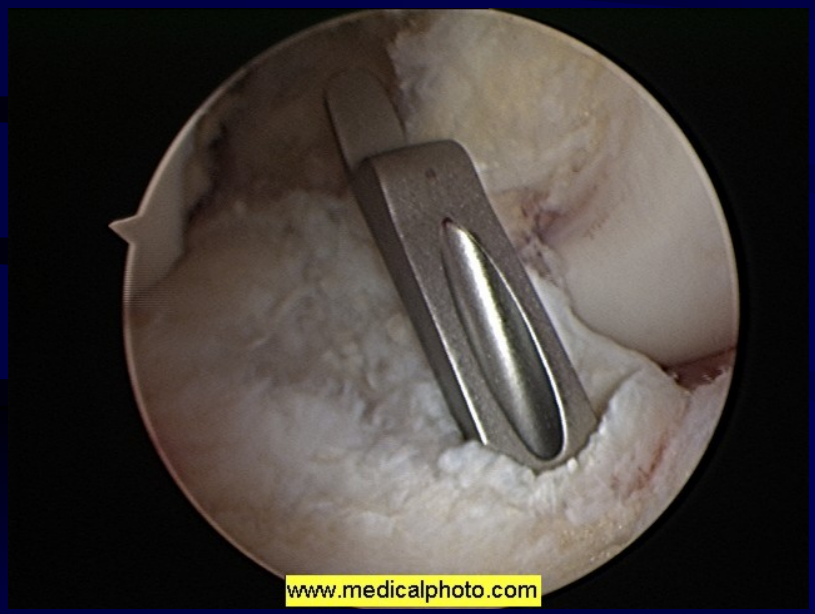
Tibial guide wire

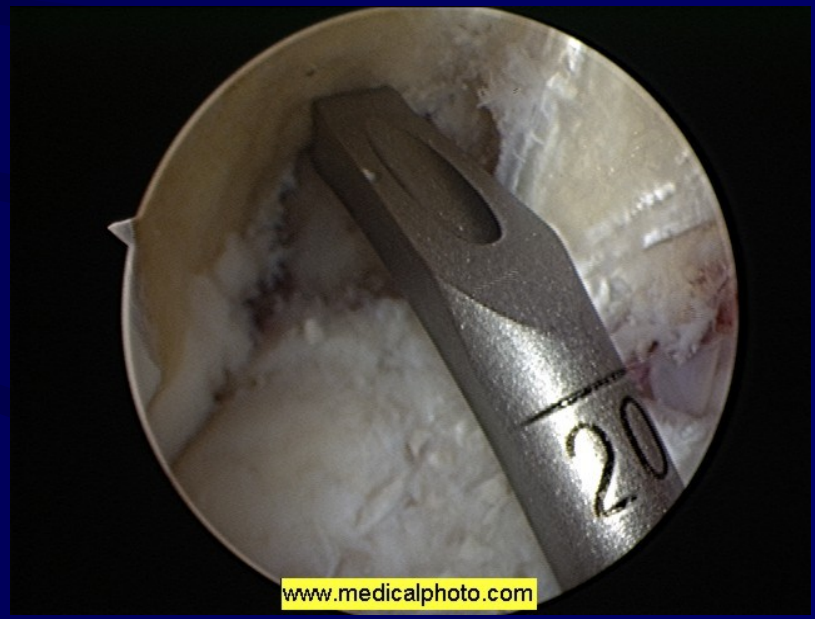


Femoral drill hole



Endoscopic view of femoral drill guide





McMaster University

Longitudinal graft tunnel motion

- Bungee effect – endobutton 1 – 3 mm
- AP motion windshield wiper effect
- May be reduced graft fixation near joint line

Graft Preconditioning and Tensioning

- Inadequate tension – continued instability, excessive tension – restrict knee motion
- Prospective, randomized study, min F/U = 2 years, grafts tensioned to 80N < laxity than the 20N, no diff. clinically
- Precise amount of tension has yet to be determined

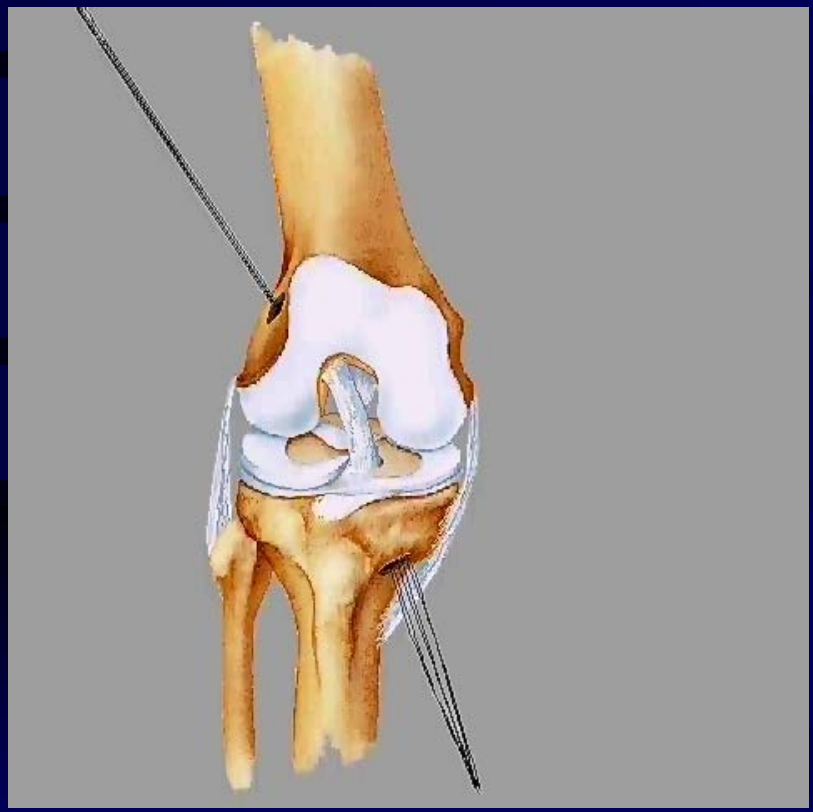
Graft Pretensioning

- May not be of benefit
- 75% viscoelasticity returns to normal one minute after fixation for:
  - 5-10lbs tension at 15^0 flexion BPTB
  - 4.5 kg – 6.75 at 20^0 to 30^0 flexion hamstring

Positioning of the graft

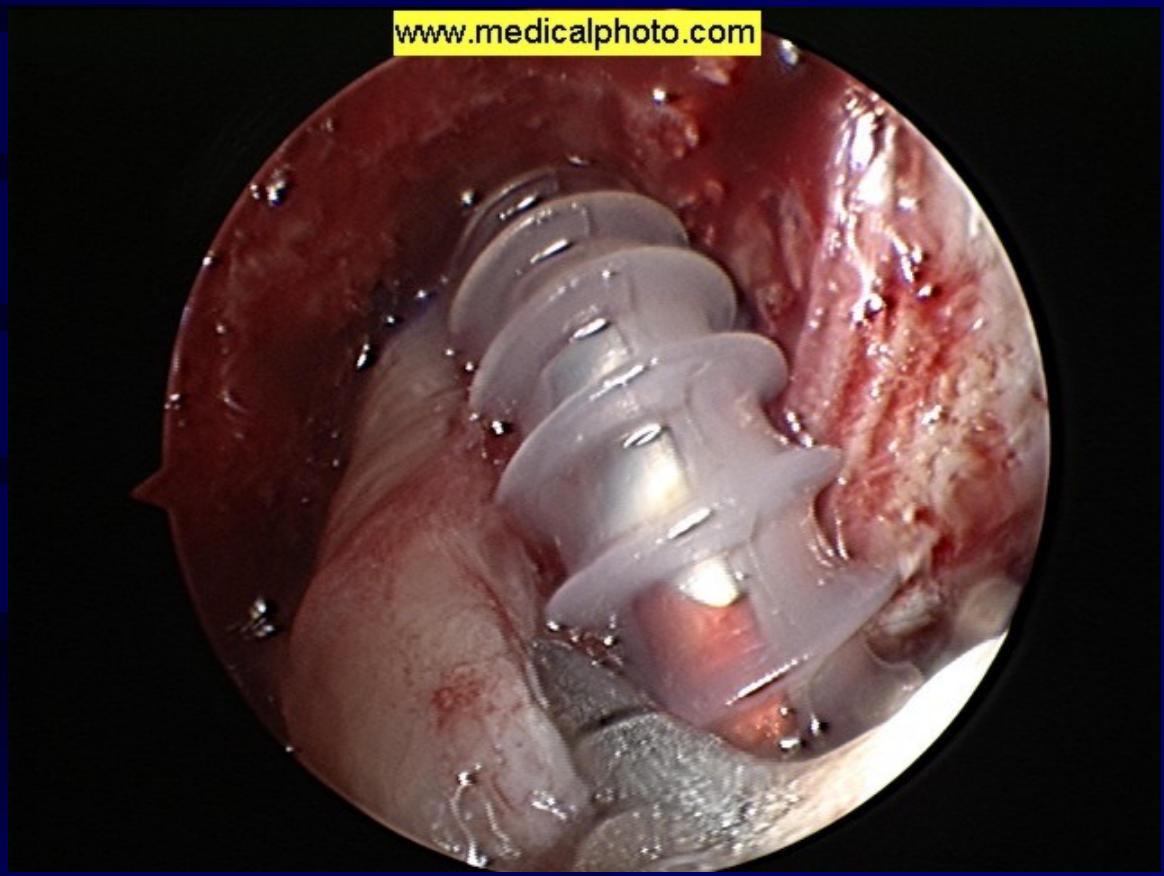
McMaster University

Insertion of Interference screws

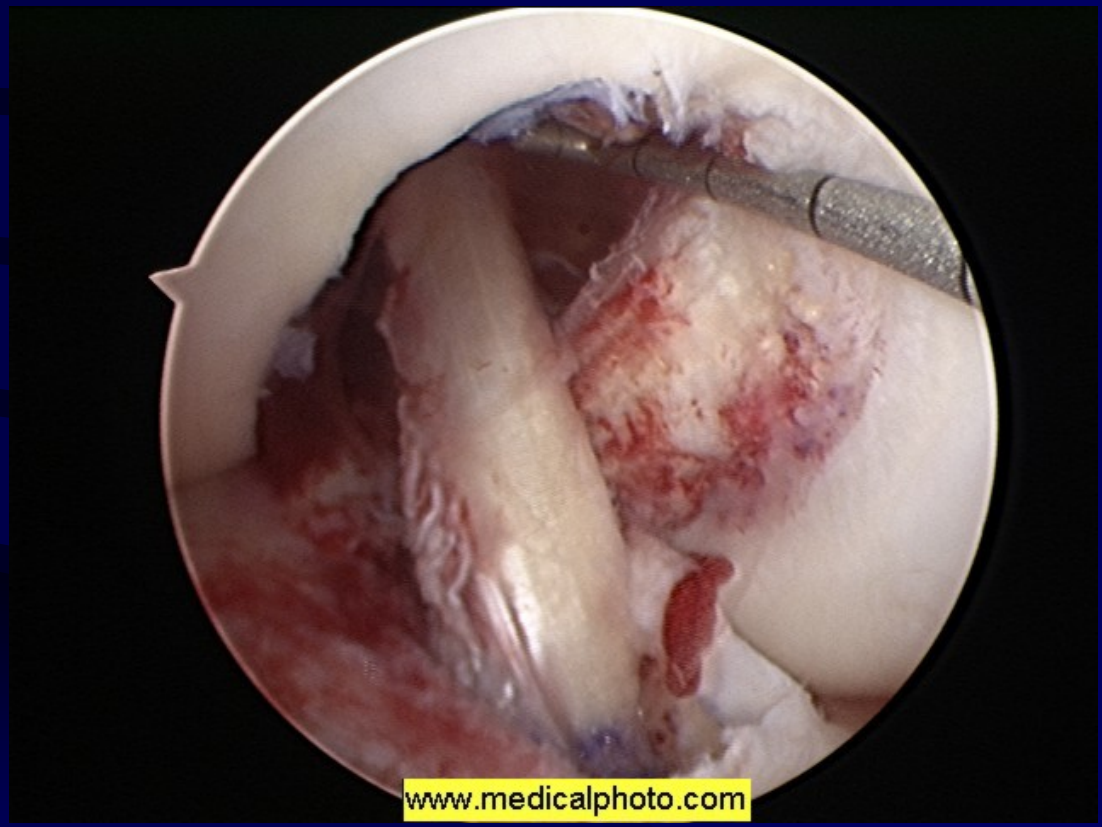


- With B-T-B, no difference if use metallic, titanium or biodegradable screws used (Benedetto et al, 1998)
- Other methods: DIRECT- staples, washers, cross-pins INDIRECT – buttons, suture posts
- Ultimate tensile loads of these devices range from 200 to 1600N

Insertion of femoral screw



Completed ACL Reconstruction



McMaster University

Graft fixation

- B-T-B, rigid fixation within osseous tunnels – healing analogous to # healing
- Soft tissue tendon grafts diff fixation – rabbit study with semi-T found increased structural properties with time, at 1 year ultimate tensile load 25% normal ACL (Blickenstaff et al, 1997)
- No definitive studies comparing biomechanical properties between bone-bone and bone-tendon healing in the ACL-reconstructed knee

McMaster University

Comparison of Donor Site morbidity (BTB + Hamstring)

- BONE-Patellar TENDON-BONE Autograft
- Patellar pain reported 4% to 40%
- Patellar baja may develop
- Incidence patellar pain lower with immediate and aggressive rehab
- Pain usually resolves after 3-6 months

- HAMSTRING TENDON Autograft
- 3 years post ham. muscle strength about 95% pre-op
- Evidence of post-harvest firm scar formation
- Soreness harvest area noted up to 3 months, not major patient complaint

McMaster University

Future directions

- Basic fibroblast growth factor

  Transforming growth factor-beta
  Platelet derived growth factor
- Enhancing ligament insertion sites
- Gene therapy
- Meniscal transplantation

McMaster University