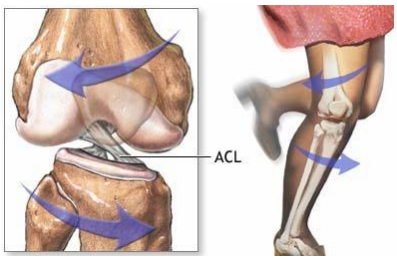
ACL rupture - History and Examination

Dr Corey Cunningham, Sports Physician

Classical history
- 70-80% non contact
- weight – bearing
- twisting
- change of direction
- change of speed
- "pop" or "snap"
- knee gives way

Contact mechanism
- 20-30% contact
- flexion / twisting
- hyperextension
  - < 15 deg bone bruise
  - > 15 deg ACL rupture



History – acute
- pain
  - immediate
  - deep
  - poorly localised
- swelling - early, large effusion
- difficulty weight bearing
- unable to continue

History – subacute
- ongoing swelling
- lack of confidence
- rotary instability
- "buckling" or "giving way"

Children and adolescents
- same mechanism
- avulsion of tibial spine
- ligament rupture

Clinical assessment
- effusion - – swipe test
- signs of ACL rupture
- signs of associated injury
  - MCL / PCL
  - meniscus

Lachman test
- valuable examination skill
- 30 deg knee flexion
- Support femur
- Translate tibia forward
  - increased range
  - lack of end feel
- 95% sensitivity / specificity

Pivot shift test
- valgus and IR force to the tibia
- move from flexion to extension
- at 15 deg flexion, ITB subluxes tibia forwards
- limited by pain, m spasm, MCL rupture
- highest sensitivity / specificity

Key points
- wt-bearing / twisting injury
- felt knee give way
- early swelling
- lack of confidence
- positive Lachman test

Imaging of The Torn ACL and Associated Injuries

Dr James Linklater, Castelreagh Imaging

Acute Knee Injury With Large Effusion

- Clinical Differential Diagnosis
  - ACL tear
  - Lateral patellar dislocation
  - Intra-articular fracture

Anterior Cruciate Ligament Tears

- X-rays are commonly normal or show a non-specific effusion

X-ray Signs of ACL Tears

- Deep sulcus sign (Figure A)
  - Translational impaction fracture anterior aspect lateral femoral condyle
- Fracture posterior rim lateral tibial plateau
- Segond Fracture (Figure B)
  - Specific indirect sign of ACL tear
  - Lateral capsular avulsion fracture
  - Uncommon
- Tibial Footprint Avulsion Fracture (Figure C)
  - More common in adolescents

Figure A

Figure B

Figure C

Further Investigation of the Acute Knee Injury: MRI Indications

- Clear ACL tear clinically ? Associated injuries
- MCL vs medial meniscal tear
- ? ACL tear / ? Patellar dislocation

MRI of ACL Tears

- High sensitivity and specificity, similar to clinical examinatio
- Slightly less accurate for partial thickness and chronic ACL tears (Figure D)
- ACL Tear Anterior displacement distal stump (Figure E)
  - Potential block to full extension

Figure D

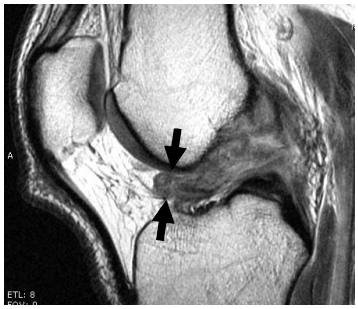
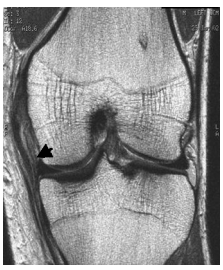


Figure E

Medial Collateral Ligament Injuries

- Well demonstrated on MRI or U/S
- Reasonable correlation with clinical grading
- Displaced Distal Superficial MCL Tear Stener equivalent



Clinical Grade 1

Clinical Grade 2

Stener quivalent

Imaging of The Torn ACL and Associated Injuries

Dr James Linklater, Castelreagh Imaging

Menisci

- Incomplete Stable Undersurface Lateral Tear (figure F)
  - No treatment required at surgery
- Peripheral Tear Posterior Horn Lateral Meniscus
- Posterior Horn Root Avulsion Lateral Meniscus (Figure G)
- Peripheral LMT & MMT
- Bucket Handle MMT (Figure H)

Figure F

Figure G

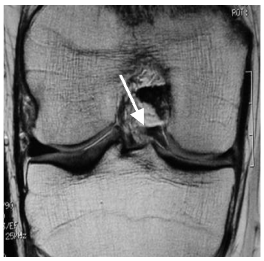


Figure H

Postero-lateral Corner

- Fibular Avulsion LCL

Acute ACL Tear

- Medial Head Gastroc Venous Thrombosis

Outcome of ACL Reconstruction

Dr Leo Pinczewski
North Sydney Orthopaedic & Sports Medicine Centre

Prospective Comparison of PT and HT graft for ACL Reconstruction over 10 years.
Leo Pinczewski, Jeff Lyman, Lucy Salmon Vivianne Russell, James Linklater. AJSM 2007 35(4) p564-74

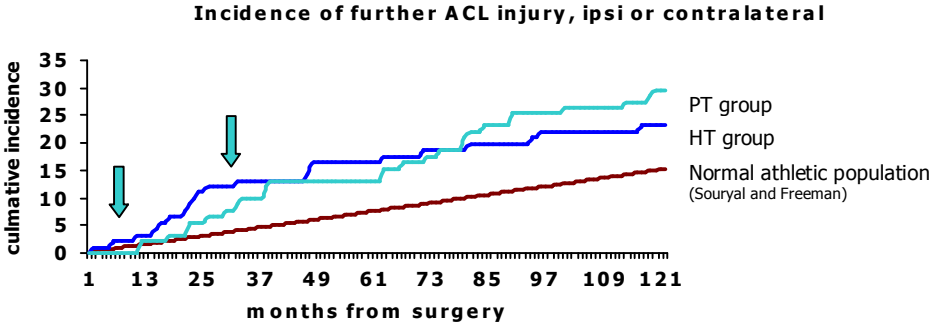
- Aim to report the long-term results of isolated endoscopic ACL surgery.
- 180 patients, 90 with PT graft and 90 with HT graft
- Reviewed prospectively and at 2, 5 7 and 10years after surgery

Results
At 10 year review no significant difference between PT and HT in

- Activity Levels
- Thigh atrophy
- Total Range of motion
- Overall IKDC
- Lachman, Pivot
- KT1000 man max
- Subjective knee function

ACL Graft rupture
- 8% in PT group 13% in HT group (p=0.24)
- Predictors of graft rupture = laxity @ 2 yrs p=0.001

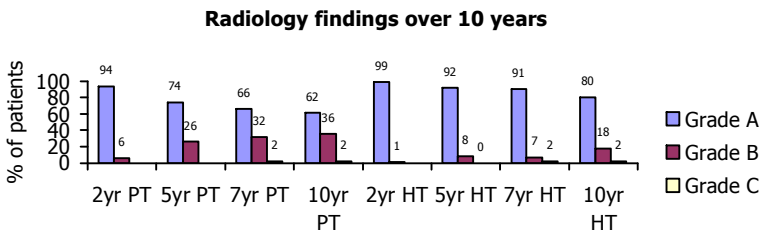
Contralateral ACL rupture
- 22% in PT group, 10% in HT group (p=0.02)
- Predictors of contralateral ACL rupture = PT graft (p=0.01) & age <21 (p=0.01)



- 30% PT, 23% HT had another ACL injury!
- Period of greatest danger 12-36 months
- PT = HT for further ACL Injury

- PT significantly higher incidence of kneeling pain at all times (p<0.05)

Radiological osteoarthritis
- Significant difference between PT and HT at 5, 7 & 10 years p<0.05



Predictors of radiological osteoarthritis
- Patellar tendon graft p=0.05
- Single leg hop test at 1 year p=0.001
- Further surgery p=0.001
- NOT Extension loss at 2 years p=0.93
  Laxity at 2 years p=0.88

Outcome of ACL Reconstruction (Continued)

Dr Leo Pinczewski
North Sydney Orthopaedic & Sports Medicine Centre

The "desired" long term outcome of ACL Surgery

- Only one knee surgery
- Subjectively feel normal knee
- no knee related reduction in activity at ANY time
- 10 year x-ray grade A
- no of fulfilling above criteria = 57/180 (32%)
- 37/90 HT (41%) vs 20/90 PT (22%) p = 0.03

Predictors of good long term outcome

- Age >21 years
- one operation
- 1 year hop >90%
- 2 year manual max <3mm
- Hamstring tendon graft

Endoscopic anatomic landmarks for tunnel placement in ACL reconstruction and their relationship to 7 year clinical outcome.

L Pinczewski, L Salmon, W Jackson, R von Bormann, P Haslam, S Tashiro. JBJS (2008)

Background:

- Multiple bundles may be superior in restoring kinematics in **cadaver** studies, but no evidence to support their superiority over single bundle techniques in **clinical** studies
- Furthermore if stability can be achieved with a **well placed** single bundle, the added complexity of multiple bundle techniques needs to be considered

Aim

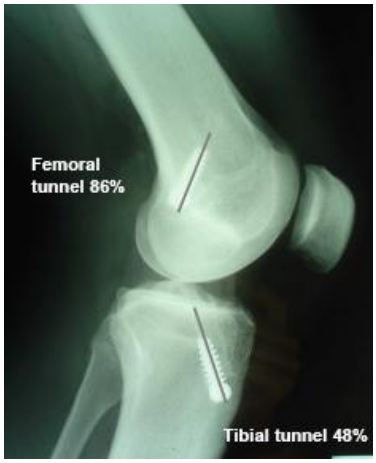
- Examine the reproducibility of using specific intraoperative landmarks to create optimal radiographic tunnel placement and clinical outcome over a 7 year study period

Methods

- 200 patients undergoing isolated ACL reconstruction followed for 7 years with full IKDC and radiographs.

Results

- Vertical grafts are associated with greater rotary instability (p=0.01) and abnormal radiographs at 7 years (p=0.01).
- Patients who had an ACL graft rupture had more posterior placement of the tibial tunnel (p=0.005).



- The tunnel placement parameters of those patients with an "ideal outcome", defined as normal or nearly normal knee function, Grade 0 pivot test, <3mm instrumented testing, full range of motion, no evidence degenerative changes on radiograph and no ACL graft rupture, are shown here

Major findings

- Intra operative landmarks result in highly reproducible tunnel placement
- posterior tibial tunnel >50% → increased graft rupture
- vertical graft angle → increased pivot and more degenerative change

Outcome of ACL Reconstruction (Continued)

Dr Leo Pinczewski
North Sydney Orthopaedic & Sports Medicine Centre

Discussion

- The described anatomic landmarks result in highly reproducible tunnel placement
- Experience of the surgeon contributes to the reproducibility in this series, but consistent and reliable landmarks can be achieved even in less experienced hands
- Studies that show poor rotary control of single bundle ACL reconstruction have failed to control graft inclination angle resulting in vertical grafts
- Multiple tunnel techniques have been advocated by these authors to better address rotary stability
- This study demonstrates that a normal lachman and pivot can be achieved with a graft inclination angle of 19^{o} using single tunnels
- Small changes in tunnel position result in increased rates of graft failure, laxity measurements, and long term degenerative change. This makes multiple tunnel techniques unlikely to be of clinical benefit

Management of Collateral Ligament Injuries when combined with Anterior Cruciate Ligament Rupture

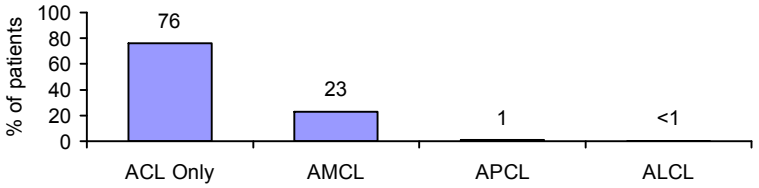
Dr Justin Roe
North Sydney Orthopaedic & Sports Medicine Centre

Incidence reported in literature:

- Approximately 20% ACL ruptures associated MCL injury (Shelbourne and Patel 1995)
- In skiers, a combined injury involving the MCL and ACL up to 57% of cases (Pressman and Johnson 2003)

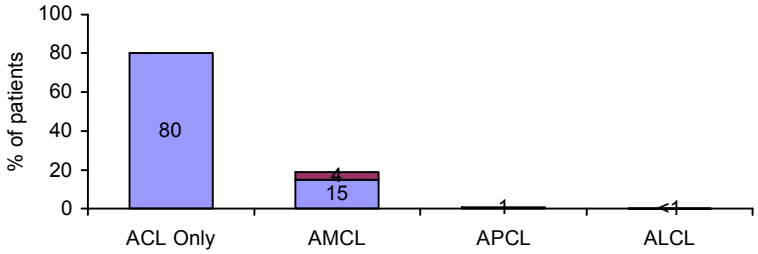
Leo Pinczewski experience:
1994 - 2005

- 5,819 ACL R/C
- 4,481 Isolated Injuries
- 1,338 Combined ACL/MCL
- Treated surgically 4%



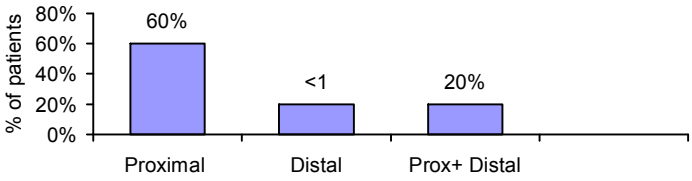
Justin Roe experience:
2004-2008

- 995 ACL R/C
- 806 Isolated Injuries
- 189 Combined ACL/MCL
- 37 Treated surgically 4%



Incidence Site of Repair

- 214 MCL/ACL Rx Surgically
- 85 Acute (40%)
- 130 Chronic (60%)
- Acute repair 51 (60%) proximally,17 (20%)distal, 17 (20%) prox+distal



Management Assumptions for Ligament Injuries

- MCL is extra articular and has a great propensity to heal
- Operative repair adds nothing to mid substance MCL rupture healing
- Synovial fluid adversely affects ligament healing
- An intact Synovium results in an intra articular effusion and prevents Synovial fluid from affecting extra articular ligament healing
- ACL surgery better carried out in subacute stage
- MCL surgery better carried out in acute stage

Management of Collateral Ligament Injuries when combined with Anterior Cruciate Ligament Rupture (continued)

Dr Justin Roe
North Sydney Orthopaedic & Sports Medicine Centre

Clinical Grading of MCL Injuries

- Sprain, no laxity, tenderness on palpation.
- Incomplete tear, some laxity, endpoint present.
- Complete tear, increased laxity (in extension), no endpoint. ?Pain.

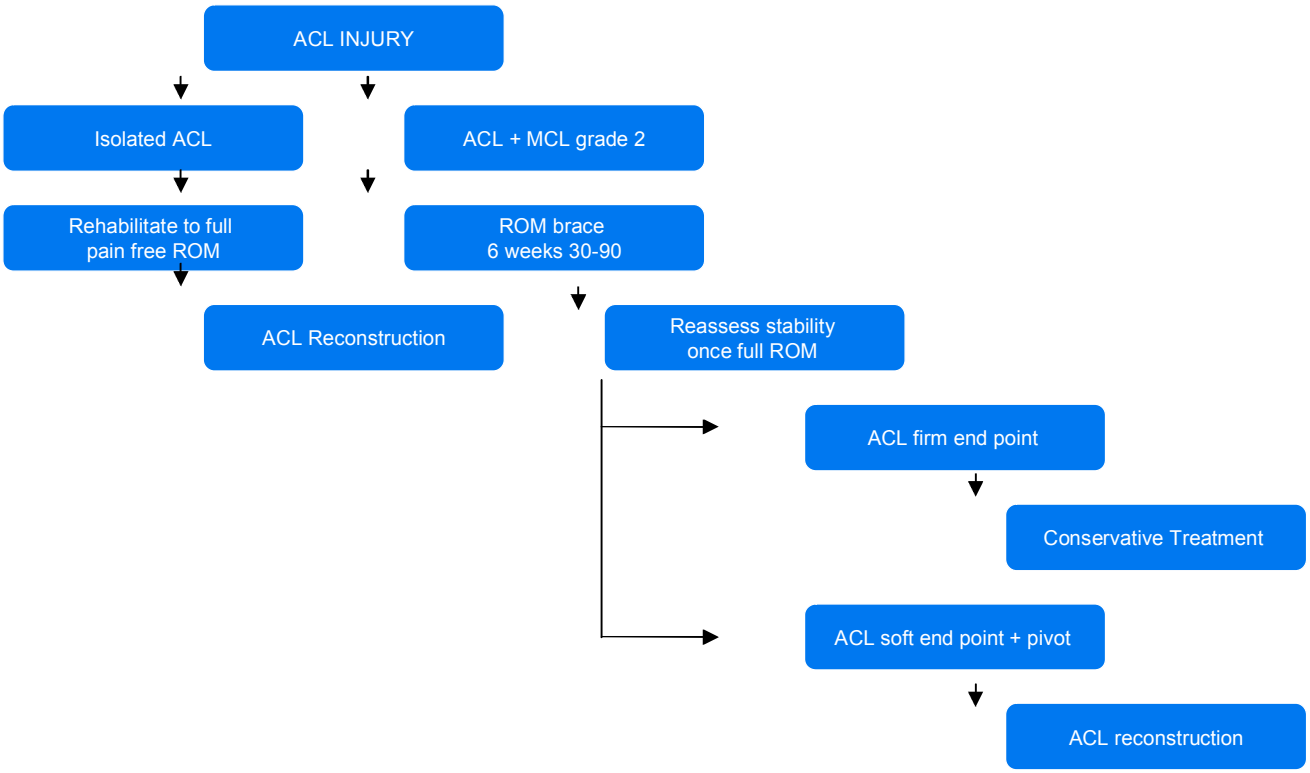
Acute Grade 1 & 2

- Effusion pain (Synovium intact), FFD
- Brace (extension block at 30 degrees) for 4-6/52, encourage full W/B
- N.B. No Arthroscopy
- Rehabilitate prior to ACL R/C on pain free mobile joint
- Prior to 1990, acute repair grade 2 MCL/ACL

Acute

- Grade 2 MCL treated conservatively since 1991
- Post 1995 reoperation rate <1%.
- Arthrofibrosis, Reflex Sympathetic O/D 0%
- Faster RTS despite delayed ACL surgery
- Grade 2 MCL invariably heals if brace within 14 days of acute injury,
- ACL sometimes heals!
- Up to 1 in 20.

Treatment Algorithm



Management of Collateral Ligament Injuries when combined with Anterior Cruciate Ligament Rupture (continued)

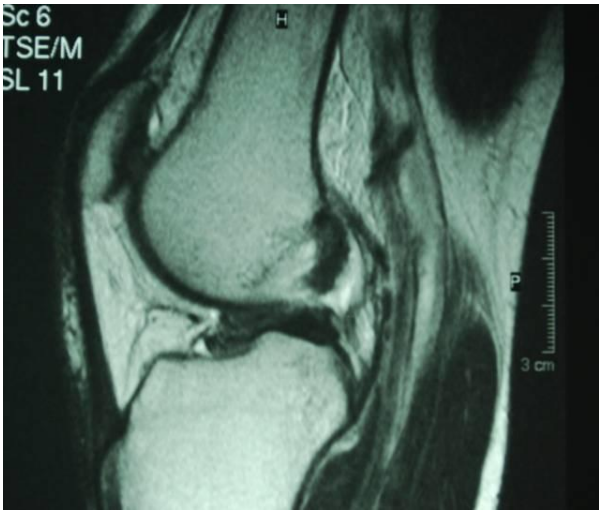
Dr Justin Roe
North Sydney Orthopaedic & Sports Medicine Centre

Management Combined ACL/MCL Injuries

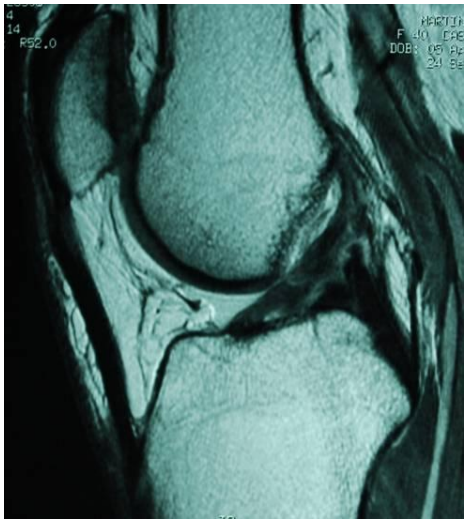
- Combined ACL/ Grade 2 MCL (proximal)
- 8 patients, Mean age 44 yrs, 50% Female
- Mechanism: 6 Skiing, 1 Rugby, 1 MBA
- Brace 30degrees, full WB x6/52
- Re-evaluated post 6 wks. Firm end-point.
- Accelerated Rehab programme
- F/U 6-12 mths, MRI, KT1000
- Additional 2 female patients failed conservative management and proceeded to acl reconstruction

Results

- Reviewed @ 6-12 mths
- Mean KT1000 = 1.9mm (Range 1-3mm)
- Unrestricted activities recommended after review
- Continued evaluation planned to 2 yrs post injury
- MRI appearances



Acute ACL injury


6 month post ACL injury

Acute Grade 3 MCL

- No Effusion, little pain, frequently swollen calf/medial thigh
- Vascular Doppler studies, arterial studies if indicated
- EUA,
- Arthroscopic assessment of synovial defect and close synovium to exclude synovial fluid from healing site
- \+ MCL repair
- \+ ACL Reconstruction
- Minimal splintage, immediate mobilization

Management of Collateral Ligament Injuries when combined with Anterior Cruciate Ligament Rupture (continued)

Dr Justin Roe
North Sydney Orthopaedic & Sports Medicine Centre

MCL Surgical assessment

- Arthroscopy, using low pressure/high volume
- assess site of synovial rupture
- Assess site of MCL laxity
    - Above meniscus, meniscus sits on tibia
    - Below meniscus(distal), meniscus sits with femur (drive-through)
    - Both above and below meniscus , meniscus sits midway between articular surfaces
- Distal MCL Rupture (drive-through)

MCL Surgical Repair

- If delay in diagnosis and treatment >14 days Rehabilitate and reconstruct MCL if > 5mm laxity or Symptomatic (Instep kickers- Soccer)
- Site of MCL laxity
    - Determines site of limited surgical exposure
- Proximal meniscofemoral laxity
    - Osteotomy of medial epicondyle and advancement of epicondyle attachment
- Distal meniscotibial laxity
    - Coronary ligament reconstruction and staple fixation of superficial MCL

Post Operative

- If Staple Fixation, Splint in Extension for 7 days, PWB Crutches 3 Weeks,
- RoM Brace
- Full RoM with Physiotherapist
- Active not Passive mobilization
- Accelerated Program.

Summary

- Isolated ACL
    - Rehabilitate and Reconstruct
- ACL / MCL Grade 1 or 2
    - Brace (extension block) x6/52, FWB
    - Rehabilitate and Reasses
    - Instability-> Reconstruct ACL
    - Stable-> Unrestricted activities and follow
- ACL / MCL Grade 3
    - Acute repair and reconstruction

Science of Rehabilitation after ACL Reconstruction

Dr Lucy Salmon
North Sydney Orthopaedic & Sports Medicine Centre

Imperative considerations
- Healing process and phases
- Evidence based science in rehab
- Many rehabilitation practices are directly related to intraoperative choices
- Implementers of rehab must respect surgeons protocol….like it or not!

"Ligamentization"
- The ACL graft is only a scaffold
- The graft remodels into a ligament
- Human data limited (Marumo, Rougraff, Falconiero)

"Ligamentization" - 4 phases
- Acute inflammatory (days)
  - ✓ Invasion of inflammatory cells
  - ✓ ischemic necrosis
- Revascularization (days to weeks)
  - ✓ New blood vessels form
  - ✓ Early scar organisation
- Proliferative phase (weeks to months)
  - ✓ Fibroblasts invade which synthesize collagen
- Collagen Remodelling (months to years)
  - ✓ gross histological structure remodelling by 12 months
  - ✓ Ultrastructure matures over 3 years

Strength and Stiffness
- At time 0 graft similar to native ACL
- But remodelling ⇩ strength and stiffness
- Period of greatest weakness is known for animals but not humans
- 1 human study strength and stiffness restored by 8 months (Beynnon 1997)

Graft fixation
- Potentially weakest link in early post op
- Most lower stiffness than ACL graft
- Potential for graft slippage
- Rehab must respect graft fixation

Neuromuscular
- Proprioception impaired 6 months
- Muscular strength impaired up to 12 months
- Muscle function impaired 18 months
  - ✓ Slower muscle reaction times
  - ✓ Altered muscle recruitment order patterns
  - ✓ Altered spinal reflexes (Wojtys 2000) in 25 ACL rec vs 40 normal

Implications
- 6 months
- Impaired graft strength and stiffness
- Unmatured collagen structure
- Impaired muscular strength and function
- "Safe" return to sport ???

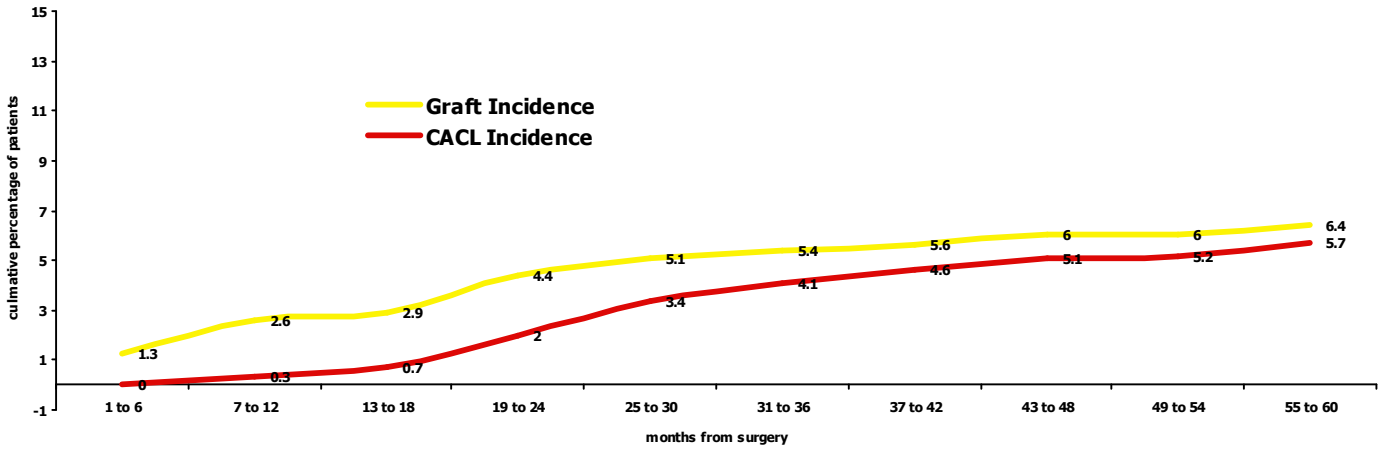
Science of Rehabilitation after ACL Reconstruction (continued)

Dr Lucy Salmon
North Sydney Orthopaedic & Sports Medicine Centre

Incidence and Risk Factors for Graft rupture and Contralateral Rupture after ACL Reconstruction

Salmon, Pinczewski et al Arthroscopy 2005

- 5 year review of 760 patients



- Graft rupture highest in first 12 months
- After 12 months ACL graft and contralateral ACL rates of injury equal 1.2% per year
- No difference between HT and PT grafts

Prehabilitation

- Only operate on pain-free mobile joints – minimizes complications
- May take weeks or months
- Patients are better able to manage postoperative exercises if they have learnt them before surgery

Stage 1 - Acute Post op - 0 -14 days

- get and apply the specific protocol from surgeon
- get patient op report
- ACL sees minimal force in ADL and CC exercises
- Immediate weight bearing 1 RCT
  - ✓ ↓pf pain, ↑VMO strength and does not ↑laxity (Tyler Clin Orth, 1998)
- CPM offers no advantage 6 RCT

Stage 2 - Muscular control - 2-6 weeks

- If the ACL is well placed - full ROM without excessive loading to graft
- Rehab must respect fixation choice
- EMG biofeedback is beneficial 1 RCT
  - ✓ ↑quads strength at 3 months, earlier full extension (Draper 1990)
- Bracing offers no advantage 11 RCT
  - ✓ No difference injuries, pain, laxity, ROM at 6 wks

Science of Rehabilitation after ACL Reconstruction (continued)

Dr Lucy Salmon
North Sydney Orthopaedic & Sports Medicine Centre

Stage 3 - Proprioception - 6 -12 weeks

- Lack of motion - suspicion of improperly placed graft
- Laxity should not be assessed until full ROM
- Resumption of solo sports skills will improve confidence and proprioception without risking graft (assuming adequate strength)
- Fixation improves with time
  - ✓ BTPB graft bone healing in tunnel in 6-8 weeks
  - ✓ HT graft ST to bone healing in 8-12 weeks
- Open Chain Exercises 5 RCT
  - ✓ Early open chain = ⇧ laxity + ⇧ pf pain (Bynum, 1995)
  - ✓ CC 6 weeks then OC = ⇧ quads, ⇧return to sport, = laxity Mikkelsen, 2000
  - ✓ Start 40-90^0 progress to 10-90^0 over 6 weeks
  - ✓ beware highly increased pf forces

- Minimally supervised rehabilitation 4 RCT
  - ✓ No significant differences laxity, strength, pain
  - ✓ 1 study better ROM in home based group Grant et al (2005) n=145
  - ✓ Largely low subject numbers, short follow up (3-12 mon)

Stage IV - Sport Specific - 3 - 5 mnth

- Graft maturation continuing
- Proprioceptive recovery vital and takes time and practice and practice and practice
- For jumpers practice good landing technique
  - ✓ ⇧ knee flexion, ⇩valgus rotation and toe land
- Normal graft strength and stiffness 8 months
- Gross histology graft remodelled by 12 months
- Maturation of the ultra-structure 3 years
- Safest to delay 12 months
- Modification to sports
  - ✓ Return to sports at ⇩ level
  - ✓ no sprigs with soccer for 1st season
  - ✓ groomed slopes and low DIN settings for skiers
- "PEP" program
  - ✓ Warm up with strengthening, plyometrics, agility drills
  - ✓ PEP program RCT 1435 female soccer (Gilchrist AJSM 2008)
  - ✓ ⇩ non contact ACL injury by 70%
  - ✓ prior ACL injury - ⇩ non contact acl injury by 5x

Stage V - Return to sport - 6 months +

- Play within confidence level
- Knee normal = Which knee?
- Approx 18 months coincides with muscular fxn
- Rate of another ACL injury > 12 months 1% per knee per year (equal graft and contralateral ACL)

POSTOPERATIVE REHABILITATION PROTOCOL FOLLOWING ACL RECONSTRUCTION

STAGE	AIMS	GOALS	TREATMENT GUIDELINES
Prehabilitation	▪ Prepare the patient for surgery	▪ Full ROM ▪ Painfree mobile joint ▪ Teach simple post op exercises	▪ Operate on pain free mobile joints – minimizes complications and speeds recovery ▪ May take many months ▪ Do not be pressured by patient into early surgery. ▪ Preprogramming post operative rehabilitation is beneficial at every level
Stage I Acute Recovery Day 1 to Day 10-14	▪ Post-operative pain relief and management of soft tissue trauma. ▪ Progress off crutches and normal gait.	▪ Wound healing. ▪ Manage the graft donor site morbidity, i.e. pain and swelling. ▪ Decrease joint swelling. ▪ Restore full extension (including hyperextension) ▪ Establish muscle control.	▪ Decrease swelling & pain with ice, elevation, co-contractions and pressure pump. ▪ Partial weight bearing to full weight bearing as pain allows. ▪ Aim for a full range of motion using active and passive techniques. ▪ Patella mobilisations to maintain patella mobility. ▪ Gait retraining with full extension at heel strike. ▪ return of co-ordinated muscle function encouraged with biofeedback. Active quadriceps strengthening is begun as a static co-contraction with hamstrings emphasising VMO control at various angles of knee flexion and progressed into weight bearing positions. ▪ Gentle hamstring stretching to minimise adhesions. ▪ Active hamstring strengthening begins with static weight bearing co-contractions and progresses to active free hamstring contractions by day 14. Resisted hamstring strengthening should be avoided for at least 6 weeks.
Stage II Hamstring And Quadriceps Control 2-6 Weeks	▪ To return the patient to normal function. ▪ Prepare the patient for Stage III.	▪ Develop good muscle control and early proprioceptive skills. ▪ If not done sooner, restore a normal gait. ▪ Reduce any persistent or recurrent effusion.	▪ Progress co-contractions for muscle control by increasing the repetitions, length of contraction and more dynamic positions, e.g. two leg quarter squats, lunges, stepping, elastic cords. ▪ Gym equipment can be introduced gradually such as stepper, leg press, mini trampoline, cross trainer. ▪ If swelling is persistent, continue with pressure pump and ice ▪ Hamstring strengthening progresses with the increased complexity and repetitions of co-contractions. Open chain hamstring exercises are commenced although often they are painful. ▪ Care must be taken as hamstring straining may occur ▪ Low resistance, high repetition weights aim to increase hamstring endurance. ▪ Continue with intensive stretching exercises. <u>Week 6:</u> ▪ Eccentric hamstring strengthening is progressed as pain allows. Hamstring curl equipment can be introduced. ▪ Consider beyond the knee joint for any deficits, e.g. gluteal control, tight hamstrings, ITB, gastrocs and soleus, etc.
Stage III Proprioception 6-12 weeks	▪ Improve neuromuscular control and proprioception.	▪ Continue to improve total leg strength. ▪ Improve endurance capacity of muscles. ▪ Improve confidence.	▪ Progress co-contractions to more dynamic movements, e.g. step lunges, half squats. ▪ Proprioceptive work more dynamic, e.g. lateral stepping, slide board etc. ▪ Can begin jogging in straight lines on the flat. ▪ Progress resistance on gym equipment such as leg press and hamstring curls. Hamstring strengthening programme aims for a progression in both power and speed of contraction. ▪ Start cycling on normal bicycle. ▪ Consider pelvic and ankle control plus cardiovascular fitness. ▪ Solo sports such as cycling, jogging and swimming are usually permitted with little or no restrictions during this stage.
Stage IV Sport Specific 12 Weeks To 5 Months	▪ Prepare to return to sport.	▪ Incorporate more sport specific activities. ▪ Introduce agility and reaction time into proprioceptive work. ▪ Increase total leg strength. ▪ Develop patient confidence.	▪ Progressing of strength work, e.g. half squats with resistance, leg press & curls, wall squats, step work on progressively higher steps, stepper & rowing machine. ▪ Proprioceptive work should include hopping and jumping activities and emphasise a good landing technique. Incorporate lateral movements. ▪ Agility work may include shuttle runs, ball skills, sideways running, skipping, etc. ▪ Low impact and step aerobics classes help with proprioception and confidence. ▪ Pool work can include using flippers. ▪ Sport specific activities will vary for the individual, e.g. Tennis - lateral step lunges, forward and backwards running drills: Skiing - slide board, lateral box stepping and jumping, zigzag hopping; Volleyball or Basketball - vertical jumps.

POSTOPERATIVE REHABILITATION PROTOCOL FOLLOWING ACL RECONSTRUCTION

STAGE	AIMS	GOALS	TREATMENT GUIDELINES
Stage V Return To Sport 5-6 Months		▪ Return to sport safely and with confidence.	▪ Continue progression of plyometrics and sport specific drills. ▪ Return to training and participating in skill exercises. ▪ Continue to improve power and endurance. ▪ Advice may be needed as to the need for modifications to be able to return to sport, e.g. Football - start back training in running shoes or short sprigs. Will usually return to lower grades initially; Skiing - stay on groomed slopes and avoid moguls and off piste initially. Racers may initially lower their DIN setting on the bindings. ▪ Train in PEP program for warm up to reduce further ACL injury *1.Warm-up (50 yards each):* • *Jog line to line of soccer field (cone to cone)* • *Shuttle run (side to side)* • *Backward running* *2. Stretching (30 s* × 2 reps each): • Calf stretch • Quadricep stretch • Figure 4 hamstring stretch • Inner thigh stretch • Hip flexor stretch 3. Strengthening: • Walking lunges (20 yards × 2 sets) • Russian hamstring (3 sets × 10 reps) • Single toe-raises (30 reps on each side) 4. Plyometrics (20 reps each): • Lateral hops over 2 to 6 inch cone • Forward/backward hops over 2 to 6 inch cone • Single leg hops over 2 to 6 inch cone • Vertical jumps with headers • Scissors jump 5. Agilities: • Shuttle run with forward/backward running (40 yards) • Diagonal runs (40 yards) • Bounding run (45–50 yards) *Ref: Gilchrist et al AJSM 2008*