

Current Trends in ACL Management

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Injury Prevention

ACL injuries in female Athletes (Hewett et al 2006)
(meta-analysis)

'all 3 studies that incorporated high-intensity plyometrics reduced ACL risk, whereas the studies that did not incorporate high-intensity plyometrics did not reduce ACL risk'

Injury Prevention

Female athletes have 4-6 fold ? risk of ACL injury compared with male counterparts.

- **Plyometric training** (high intensity)
- **Biomechanics analysis and feedback** (eg. Leg alignment)
- **Technique training** (eg jump landing)
- Strength training
- Balance & core stability training

Hewett, L. et al (2006)

ACL injuries in female athletes – part 2, a meta-analysis of neuromuscular interventions aimed at injury prevention

PEP programme

Santa Monica Orthopaedic & Sports
Medicine Group

www.aclprevent.com



Landing technique

Drop jump screening test – Noyes 2007



Depth of flexion on landing



Split squat to check alignment and control

Incidence of Re-injury

- <18 - 25%
- 18 - 25 - 10%
- >25 - 5%

Arthrofibrosis

- early 1980's - 19%
- >1996 - 1%

Shelbourne

Mechanism of ACL injury

- Non-contact injury at contact sports (72%)
- Sudden deceleration followed by change of direction or landing motion (often valgus)
- Majority with foot-strike *near* full extension
- Quads implicated (with lax hams) in straining ACL with max eccentric contraction

Boden et al, 2000.

Clinical Examination:



Lachman's test

- Very sensitive and specific for ACL

Malanga GA, Andrus S, Nadler SF, McLean J. Physical examination of the knee: a review of the original test description and scientific validity of common orthopedic tests. Arch Phys Med & Rehab 2003; 84(4):592-603.



- Low correlation with subjective instability

Feagin's test

Feagin JA, Coole TD. Prone examination for ACL insufficiency. JBJS 1989; 71-B:863



Lateral Pivot Shift

- Principle: Easy anterior subluxation of lateral femoral condyle
- Components:
 - Full (hyper) extension
 - Patient relaxed
 - Lift foot and suspend knee
 - Simultaneous valgus and internal rotation
 - LTC now subluxed (you can't see this yet)
 - Flexion, keeping valg/IR stress: LTC reduces with a palpable / visible clunk / shift/ glide

The lateral pivot shift sign

High correlation with subjective instability

Malanga GA, Andrus S, Nadler SF, McLean J. Physical examination of the knee: a review of the original test description and scientific validity of common orthopedic tests. Arch Phys Med & Rehab 2003; 84(4):592-603.

Closed Kinetic Chain Exercises

Strain on the ACL:

- CKC exercises do NOT shield the ACL totally from strain – peak strain on the ACL during OKC active extension and bilateral squatting are equal (Beynon et al 1997)

However

- ↑ resistance in OKC ex's increases ACL strain
- ↑ load in CKC ex's does NOT increase ACL strain. (Fleming et al 2003)

Closed Kinetic Chain Exercises

- Step ups
 - Step downs
 - Lunge
 - Unilateral sit to stand
- No significant difference between them, these results are similar to previously studied tests ie. squatting and active extension (Hejine et al 2004)

Open Kinetic Chain Exercises

It is only OKC quadriceps exercises which compromise the ACL & then only in 0-50° range

Rank comparison of peak ACL strain values during commonly prescribed rehabilitation exercises (mean ± SE)

Rehabilitation Activity	Peak strain	No. of Subjects
Isometric quadriceps contraction @ 15° (30 Nm of extension torque)	4.4 (0.6) %	8
Squatting w/ sport cord	4.0 (0.6) %	8
Active flexion-extension of the knee with 45-N weight boot	3.8 (0.5) %	9
Lachman test (150 N of anterior shear load; 30° flexion)	3.7 (0.8) %	10
Squatting	3.6 (0.5) %	8
Active flexion-extension (no weight boot) of the knee	2.8 (0.8) %	18
Simultaneous quadriceps and hamstrings contraction @ 15°	2.8 (0.9) %	8
Isometric quadriceps contraction @ 30° (30 Nm of extension torque)	2.7 (0.5) %	18
Stationary bicycling	2.7 (1.2) %	5
Weightbearing @ 20° of knee flexion	2.1 (0.5) %	11
Anterior drawer (150 N of anterior shear load; 90° flexion)	1.8 (0.9) %	10
Stationary bicycling	1.7 (0.7) %	8
Isometric hamstrings contraction @ 15° (to -10 N-m of flexion torque)	0.6 (0.9) %	8
Simultaneous quadriceps and hamstrings contraction @ 30°	0.4 (0.5) %	8
Passive flexion-extension of the knee	0.1 (0.9) %	10
Isometric quadriceps contraction @ 60° (30 Nm of extension torque)	0.0 %	8
Isometric quadriceps contraction @ 90° (30 Nm of extension torque)	0.0 %	18
Simultaneous quadriceps and hamstrings contraction @ 60°	0.0 %	8
Simultaneous quadriceps and hamstrings contraction @ 90°	0.0 %	8
Isometric hamstrings contraction @ 30°, 60° and 90° (-10 N-m of flexion torque)	0.0 %	8

- Peak ACL strain occurs when the knee is flexed at smaller angles - ie. 20-30°
- ↑ knee flexion angle ↓ ACL strain - ?
Due to increased hamstring activity with greater hip flexion

“At this time it is not possible to identify which exercises are safe or harmful to a healing graft because strain thresholds that are beneficial and/or detrimental to graft healing remain unknown”

(Heijne et al 2004)

Treatment

- ↑ ROM = to other side (ext & flexion).
- Facilitate hamstring function.
- (Positive pivot shift - add resisted ext tibial rotation with knee flexion - esp eccentric.)
- Progressive strengthening:
 - PNF/NWB ex's
 - Bilat WB ex's
 - Unilat WB ex's
 - Unidirectional
 - Multidirectional



Include:

- Balance
- Proprioception
- Endurance
- Agility
- Sport/occupation specific activities

Potential problems in the ACL deficient knee

- Recurrent meniscal tears
- Advanced joint surface erosion
- Progressively increasing laxity
- Chronic synovitis

Improper rehabilitation can elicit or accelerate these symptoms

Indications for Surgery

- **Instability**
- **Activity level**
- **Age ??????????**

Timing of surgery:

What is urgent?

- Ligament repair – **urgent** (within a few days)
- Ligament reconstruction - not urgent
Optimum time 4 weeks
- Meniscus: Partial menisectomy: non-urgent
Meniscal repair: better early
Bucket handle tear with locked knee: **urgent**
- Knee dislocation: **urgent hospitalisation** -
Check for vascular damage

Patellar tendon graft

- Advantages
- Disadvantages
- Indications

Quads tendon graft

- Advantages
- Disadvantages
- Indications

Hamstring tendon graft

- Advantages
- Disadvantages
- Indications

Double Bundle Technique

- Postero-lateral bundle - controls rotational stability
- Antero-medial bundle - controls A/P stability

Allograft

Healing / Ligamentisation

- Graft necrosis
- Revascularisation
- Cellular population
- Collagen deposition
- Maturation

Vascular Response

Autografts:

- 6 wks – graft shows avascular necrosis surrounded by a vascular synovial sheath
- 8-10 wks – graft invaded by budding capillaries
- 16 wks – near complete revascularisation
- 20wks - revascularised

- Graft plays innocent role in the race between avascular necrosis & revascularisation
- Revascularisation takes place from the ends of the graft towards the middle
- Nutrition to the graft is by diffusion from synovial fluid
- The tibial remnant of the ACL & the fat pad are important structures for synovialisation & vascularisation & ? feedback mechanism.

ACL graft at 3 months post-op



Tensile Strength

- Autografts are strongest at the time of transplantation
- Tensile strength ? during first 12 weeks
- Strength then ? over next 9 – 12 months

Fixation

PTG: bone on bone healing – secure by 6-8 weeks

Hamstring graft: soft tissue/bone healing – 8-12 weeks

Rodeo, Scott et al (1991)
Scranton, Pierce et al (1998)

Four Phases Of Rehabilitation

Shelbourne et al.(1992)

Phase 1 – Pre-operative Phase

Focuses on:

- Resolving swelling
- Regaining maximum range of movement
- Initiating a strengthening programme
- Mental preparation by the patient

Goal of Phase 1

To prepare the patient for surgery with a full understanding of the operative and post-operative procedures.

Phase 2 – Initial Post-operative Phase

Focuses on

- regaining active and passive knee movement
full extension (hyperextension)
flexion to 90 degrees
- wound healing
- maintenance of active quadriceps control
- early functional weight bearing
- closed kinetic chain activity

Mobilisation

Early range of motion exercises will prevent adhesion formation and tightening of soft tissues around the joint, thereby restricting the development of contractures or excessive scar tissue



Loss of full extension increases patello-femoral contact forces and contributes to quadriceps weakness (Sachs et al)

Aims:

- Flexion = to opposite side
- Extension = to opposite side

Phase 3 – Progressive Rehabilitation

- Focuses on
 - restoration of improved motor function
 - restoring a normal gait pattern
 - increasing flexion to 135 degrees
 - improve muscle timing, coordination and strength training
 - progress functional activity

Phase 4 – Fully Integrated Function

Focuses on

- restoration of full function
- sport/ work specific training
- return to sport/work on reaching 70% of the strength of the unaffected leg

Monitor all stages, progression is dependent on swelling and range of motion

Integrated rehabilitation (functional testing algorithm)

Davies' sequential testing series:

- Basic measurements – VAS for pain
AROM; PROM (<10% diff)
- KT2000 (<3mm diff – normal, if >3mm – guarded progression)
- Proprioception / balance tests (<10%? progress)
- Closed chain testing – linea bilat isokinetic (<30% diff? progress)

- Open chain testing - isokinetic

Why test?

' If a muscle cannot function in an isolated muscle test then it cannot function in an integrated kinematic movement'

When safe to test?

BPTB - >6wks FSHG – 8-12wks
(if slightly lax consider ROM)

Progress if <25% diff.

- **Functional tests:**

1. Bilat squat – even weight (broom scales)
2. Functional jump tests-bilat - single jump for distance. (males 100% height; females 90% height)
3. Functional hop tests – uninv leg then inv leg
4. Lower extremity function test
5. Sports specific tests

NB look at quality of movement in each test, not just distance – good control is imperative

Donald Shelbourne Current Ideas (2003)

- Primary aim is to regain limb symmetry
- Avoid haemarthrosis & gross effusion – bed rest X 1 week, CPM & cryocuff
- Use of contra-lateral graft to avoid clash of treatment principles in the early stages
- Mechanism of injury

Mastrokalos et al, May 2005

“ The contra-lateral bone-patellar tendon graft appears to present no advantage over the ipsilateral graft, as all symptoms concerning donor site morbidity are shifted from the injured into the healthy knee, and return to activity is **not** more rapid”

Comparison of PTG & Hamstring Grafts

These authors all found results comparable:

- Maeda et al 1996
- Siegal & Barber-Westin 1998
- Corry et al 1999
- Eriksson et al 2000
- Aune et al 2001
- Beard et al 2001
- Goradia & Grana 2001

Increased Laxity in FSHG subjects

- Aglietti et al 1994
- Barrett et al 2002
- Beynnon et al 2002

NO increase in laxity:

- Cooley et al 2001
- Corry et al 1999

More restricted rehabilitation for FSHG

- Siegal & Barber-Westin 1998
- Fu et al 2000
- Barrett et al 2002

Restriction not required:

- Howell & Taylor 1996
- Corry et al 1999

Females & the FSHG

- Barrett et al 2002:
PTG – 8% failure rate
FSHG - 23% failure rate
- Corry et al 1999
- Noojn et al 2000

Tibial Tunnel Widening

- Occurs in FSHG > PTG subjects
- ↑ with accelerated rehabilitation
- 75% widening occurs in first 3 months (Hantes et al 2004)
- 50% occurs in first 6 weeks, before biological graft incorporation (Fink et al 2001)
- Expansion occurs over time – 1-12 weeks, not immediately after surgery (Buck et al 2004)

Reading the Literature

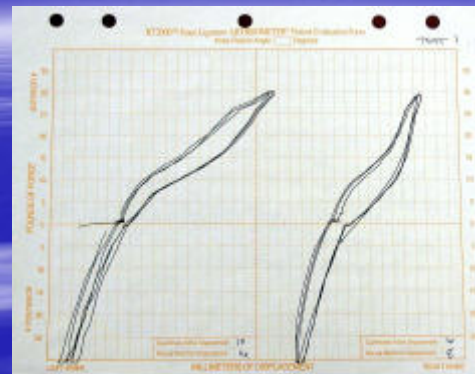
Outcome measures:

- Stability – KT2000; Lachman
- Function
- Patient Satisfaction

Laxity tests:

- Commonly used to measure success of reconstructive surgery
- **NO** correlation between laxity test results and any function test or patient satisfaction results

(Harter et al, 1988; La voie et al, 2001; Kocher et al, 2002)



Functional Performance Tests:

Lephart et al (1991)

- Co-contraction test – timed side-stepping using rubber cord
- Carioca test – timed
- Shuttle runs – timed

? What is target / normal for each subject

? Useful for monitoring progress

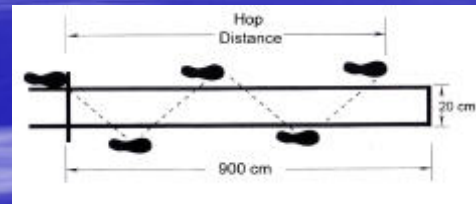
Single leg hop tests:

>15% limb difference is classed as abnormal (Barber et al 1992)

- Timed 6 metre hop (Barber et al 1990)
- Single hop for distance
- Triple hop for distance
- Cross-over hop for distance (Noyes et al 1991)
- Stair hop
- Vertical hop (Hopper et al 2002)
- Adapted cross-over hop test (Clarke et al 2002)

- Hop test asymmetry correlates with low velocity isokinetic results (Noyes 1991; Jarvela 2001)
- Test – retest reliability in ACL reconstruction subjects at 1 yr post-op (Hopper et al 2002)
- Eastlack et al (1998) compared copers and non-copers following ACL injury & found the cross-over hop test to be the most discriminatory (lateral movements)

Adapted cross-over hop test (Clark *et al*, 2002)



Scoring systems:

- Lysholm knee scoring scale: specific to activities of daily living & symptoms. Scores out of 100
 - Tegner activity scale: work / sport related activities. Scores 1-10
 - IKDC subjective evaluation form: Complicated scoring system
- (David Johnson & Roger Smith, 2001)