Why is Anterior Cruciate Ligament Rehabilitation Still Challenging?

Anterior Cruciate Ligament Rehabilitation
Female: ACL Injury – What do we think we know?

- Female injury risk is somewhere in the range of 4 to 8 times that of male participants in the same or comparable activities: Non-contact
- Highest risk sports for females are basketball and soccer
- Biomechanical risk factors:
  - Ligament laxity
  - Hormonal influences
  - Muscle firing patterns
  - Landing strategies
  - Proprioceptive characteristics

Reference: Clinical Commentary
Albaugh J, Friedman J, Cody S, Ganley T: Training – Conditioning April 2010

Considerations for the Female ACL Patients

- Females are quadriceps dominant (muscle firing patterns)
- Balanced landing position – knees stay well centered over the toes on firm foot/ankle platform, flexed hip and knee in neutral rotation without excessive Abduction or Adduction (Valgus position with external rotation)
- Preventive training programs:
  - Warm-up and functional mobility
  - Strengthening of the hamstrings and hip core muscles to change the firing patterns
  - Proprioceptive/balance neuromuscular control

ACL Injury – Younger Patients

- Pre-pubescent – Adolescent concerns of the growth plates and smaller anatomical features
- Post-operative rehabilitation is typically slower with longer periods of regaining motion and strength: pre-pubescent may be 3 months slower than older adolescents.
- Balance and proprioceptive activities are just as important
- Most challenging concerns for this age group is some patients are often less compliant
- Bracing may be good intervention for safe return to athletic activities
ACL – Graft Selection

1. Autograft
   Bone-Patella Tendon – Bone
   Hamstrings: Semitendinosus – gracilis
   Double bundle - tunnels

2. Allograft
   Bone-Tendon-Bone
   Achilles Tendon with bone
   Anterior Tibialis

3. Contra-Lateral Transplant

Double-Bundle ACL Reconstruction

- Biomechanical studies, reconstruction of AM and PL bundle better in ant and rotational stability
- Several clinical trials in progress but none have shown superiority over single bundle technique
- Important technical issues must be overcome to adopt procedure
Technical Hurdles - Tibia

- Average AP length of tibial footprint is 14mm (range 9 to 18mm)
- Natural center of AM and PL bundles are only 5mm apart
- "Experts" recommend 2mm bone bridge between tunnels
- Tibial footprint is generally too narrow to place 2 separate bone tunnels in the ML direction

Technical Hurdles - Tibia

- Original sagittal courses of both footprints need to be changed in order to place 2 bone tunnels
- In order to reproduce DB tibial anatomy tunnels must be less than 5 or 6mm and communicate

Technical Hurdles - Femur

- Due to limitations in tunnel angles footprints less than 18mm in prox/dist diameter render anatomic placement of femoral tunnels impossible
- Basically...
  With standard graft sizes there’s NOT ENOUGH ROOM for 2 femoral tunnels without convergance
Technical Hurdles – Notch/PCL Impingement

- Grafts larger than 7-8mm will impinge in extension without notchplasty
- More superior AM tunnel will impinge against PCL in both flexion and extension
- Combined diameter of grafts 12-14mm may cause "overstuffing of intracondylar notch"
Double-bundle clinical results

- Zhao et al. Knee 2006, 43 pts, chronic ACL ruptures, 4 tunnels and 8-stranded hamstring grafts, 95% patients with neg pivot shift, and 1mm max KT-1000 tests

- Colombet et al. Knee Surg Sports Traumaol Arthrosc. 2006, 33 pts, 4 tunnel with autologous hamstrings, 2 yr f/u, 84% neg pivot shift, KT-1000 .9 mm, return to previous sports 75%

- Siebold et al. Arthroscopy 2008, 70 pts, prospective, randomized clinical trial, SB vs DB 4-tunnel with autologous hamstrings, 19 month f/u, 97% neg pivot shift in DB group, 71% neg in SB group, KT-1000, 1mm in DB group, 1.6 mm in SB group, no sig difference in IKDC scores between groups, 1 traumatic DB failure at 11 mo
Evidence Based Practice

Levels of Evidence
I. High – quality of diagnostic studies, prospective studies or controlled trials
II. Lesser – quality studies < 80% follow-up
III. Case controlled studies
IV. Case series
V. Expert opinion – clinical commentary

Center for Evidence-based Medicine, Oxford, United Kingdom

Grades of Recommendation Based on Strength of Evidence
A. Strong Evidence – level I on level II
B. Moderate Evidence – single high quality randomized controlled study level II
C. Weak Evidence – single level II or preponderance of level III or IV
D. Conflicting Evidence – higher quality studies on a topic that disagree with respect to their conclusions
E. Theoretical/Foundational Evidence – preponderance of evidence for animal or cadaver studies
F. Expert Opinion – best practice based on the clinical experience


Reconsiderations of Common Interventions
• CPM
• Early weight bearing
• Immediate versus delayed mobilization
• Cryotherapy
• Supervised rehabilitation
• Therapeutic exercises
• Neuromuscular electrical stimulation
• Neuromuscular re-education
• Accelerated rehabilitation
• Eccentric strengthening
• Knee bracing
Recommendations Based on Evidence

- CPM – grade C – weak evidence
- Early weight bearing – Grade C – weak evidence
  - Standard opinion – this doesn’t cause negative effects and may decrease anterior knee pain
- Immediate motion – Grade B – moderate evidence
- Cryotherapy – Grade C – weak evidence
- Supervised Rehabilitation – Grade B – moderate evidence
- Therapeutic exercises – Grade A – strong evidence
  - Use of OKC and CKC are supported

Recommendations Based on Evidence

- Neuromuscular electrical stimulation – grade B
- Neuromuscular re-education – grade B
- Accelerated rehabilitation – grade B
  - No evidence exists to determine the safety of early return to sports
- Eccentric strengthening – grade B
- Knee bracing:
  - Conflicting evidence exists for the use of functional bracing – grade D – conflicting evidence
  - Use of post-op bracing may not be more beneficial – grade B
  - Functional bracing appears to be beneficial in ACL deficient patients – grade C

Reference: JOSPT, April 2010

Phases of ACL Rehab

- I Pre-Functional
- II Return to Function
- III Return to Activity
Functional Progression – ACL

Pre-functional – phase one

• Mobility
  – Full normal extension
  – Flexion as tolerated – but not pushed
    • CPM is for extension not flexion
  – Patella mobility – all direction
  – Hip mobility to assist with core stabilization
Functional Progression – ACL

Pre-functional – phase one

• Recruitment
  – Core stabilization – swiss/plyo-ball exercises
  – Co-contraction hamstrings over the quadriceps
  – Leg control – standing SLR
  – Quadriceps isometrics – sub-maximum
  – Eccentric hamstrings control 30° → 90°
Hamstrings - Revisited

- Based on EMG studies
- Hamstrings create a posterior directed force on the tibia when the flexion angle is 30° or greater
- Hamstrings function as an eccentric control of hip flexion
- Is the hamstrings the true core muscle group of the lower extremity?


Functional Progression – ACL

Pre-functional – phase one
- Tri-plane stabilization
  - Mini squats – double leg
  - Standing terminal extension (STE)
  - Balance weight shift exercises
  - Leg press sub-max double leg.

References: Gerber, etal. 2007
Functional Progression – ACL
Return to Function – Phase Two

• Mobility
  – Full ROM extension & flexion
  – Hamstrings – functional re-lengthening
  – Heel cord re-lengthening

• Recruitment
  – PRE – hamstrings 30°→ 90°
  – PRE – quadriceps 45°→ 90°
  – PRE – hip strengthening – all planes
  – Advanced core exercises – hamstrings – bridge row
  – High speed isokinetics
Anterior Translation - ATT

- Least Amount of ATT – 75 Deg. Knee Flexion
- Maximum Amount of ATT 45 – 15 Deg. Flexion (Based on Maximum Isometric Quadriceps Contraction)


Open- or Closed-Kinetic Chain Exercises After Anterior Cruciate Ligament Reconstruction?

- OKC and CKC Exercises both produce strains on the ACL in terminal extension
- OKC with increase of resistance does increase ACL strain
- CKC does not increase the ACL strain with increase load


Clinical Application of the Research

- OKC short arc flexion moment angle continues to be suggested (90° – 40°)
- Increase external compression (weights) with increase strain on the ACL toward extension
- Early use of CKC is still recommended
Functional Progression – ACL
Return to Function – Phase Two

• Tri-plane stabilization
  – Balance activities – balance board – BOSU
  – Progress to single leg squat on uneven surfaces
  – Balance vector – 3 planes
  – Leg press total gym single leg
  – Lateral step-up and lunges
  – Slide board – FITTER
  – Plyo-toss with squat

Reference: Risberg, Holm, Myklebust, Engebretsen 2007
Functional Progression – ACL
Return to Activity Phase three

- Mobility
  - Any incomplete motion concerns mobilization as needed
  - Advanced functional LE re-lengthening
- Recruitment
  - Advanced quadriceps strengthening
  - Open kinetic chain progression
Functional Progression – ACL
Return to Activity Phase three

• Tri-plane stabilization
  – Advanced plyo-toss on uneven surfaces – BOSU
  – Perturbation training
  – Advanced balance vector training – eyes closed
  – Fitter, stepper, elliptical, versa climber, slide board for endurance training
  – Plyometric jumps – double to single leg
  – Lunges with weights
  – Sports Specific Training
    • Box Runs, Lateral Running, Retro sprinting, Vertical Jumps, Figure 8 run/cuts, running program.
FUNCTIONAL LOWER EXTREMITY TESTING

• Balance testing – eyes open and closed
• Balance vector testing
• Leg press test
• Isolated strength assessment (Isotonic vs. Isokinetic)
• Return to Sports – Functional Testing
  • Jump test – Double leg
  • Hop test – Time and distance – Single leg

Reference: Reid A, Birmingham TB, Stratford PW, Alcock GK, Griffin RJ. Hop Testing Provides a Reliable and Valid Outcome Measure During Rehabilitation After Anterior Cruciate Ligament Reconstruction. Phys Ther (87) 337-349; 2007

Static and Dynamic Standing Balance

• Eyes Closed Static (ECS)
• Eyes Open Dynamic (EOD)
• Eyes Closed Dynamic (ECD)

Clinical Measurement Tool
Eyes Closed Dynamic time based testing is an appropriate and reliable clinical measurement in adolescents.


Plyometric Training

Progressive in nature
• Increased number of exercises
• Increase repetitions and sets
• Decrease rest periods
  – Straight jumps -> Sagittal
  – Lateral jumps -> Frontal
  – Combination -> Transverse
• Frequency – three times a week
• Intensity – double leg jumps to single leg jumps
• Low intensity – 100 - 200 fast contacts
• Moderate intensity – 200 - 400 fast contacts
• High intensity – 400 – 600 fast contacts
ATHLETIC REHAB INSTITUTE

FUNCTIONAL PROGRESSION

<table>
<thead>
<tr>
<th>Program</th>
<th>Duration</th>
<th>Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walk Program</td>
<td>20 Minutes</td>
<td>Treadmill-Retro (Backwards)</td>
</tr>
<tr>
<td>Jog Program</td>
<td>Goal 10-15 Minutes</td>
<td>Mix of Retro and Forward</td>
</tr>
<tr>
<td>Running Program</td>
<td>Straight Running</td>
<td>3-5 miles at 7/8 min/mile on track</td>
</tr>
<tr>
<td></td>
<td>Goal: increase to sprint (Add any equipment once patient can sprint)</td>
<td></td>
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</tbody>
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What is Function?

- Mobility – R.O.M.

- Recruitment
  - OKC – CKC Strengthening

- Tri-Plane Stabilization
  - Neuromuscular Proprioception
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Questions