Rehabilitation after
Double-Looped STG
ACL Reconstruction

Steven M. Traina, M.D.
Western Orthopaedics
Denver, Colorado

Rehabilitation

• Pre-op
  – Knee Status
  – Mental Status
• Operative
  – Technical Considerations
• Post-Op
• “Rehabilitation”
• Return to Play
Final outcome not significantly different between BTB vs. STG ACL Reconstruction

BUT

Trend is Less Patient Morbidity in STG Group and Quicker Rehab

FACT

Pinczewski; AJSM 2002
Beynnon; JBJS 2002
Shares; AJSM, 2002
Aglietti; AJSM 994
Mander; AJSM 1991
O'Neill; JBJS 1996
Corry; AJSM, 1994
Jansson, AJSM, 2003
Karlson, AJSM, 2003

FACTS

Accelerated Rehabilitation Requires Excellent Fixation of Graft to Bone Construct

• “Weak Link” of soft tissue grafts resulting in stretching of graft or failure and reason for poor reputation of STG in past
• Longer tunnel graft healing time than bone to bone
• Not all STG ACL Reconstructions are the same
  – Dependent on fixation system

  2000  Brand; AJSM
  2003  Kousa, AJSM
Injury

Knee Status

• Swelling
• Range of Motion
• Muscle Strength
Mental Status “Toughest Patient”

- Emotionally Labile
  - Angry, Upset, Scared, Depressed
- Entourage
  - Parents, Trainers, Coaches, Agents
- Questions
  - Internet, Engineers, Networked
- Expectations
  - May be Unrealistic

Pre-Op

Mental Status

Solution

- Spend Time
- Literature
- Education on Expectations
Arthrofibrosis

- Timing of surgery based on status of knee

Pre-Op

Not All ACL Injuries the Same

- Earlier time to surgery
- Ultimately better result

Shelbourne; et al AJSM 1991
Harner; et al, AJSM, 1992
Wasilewski; et al, AJSM, 1993
Not All ACL Injuries the Same

Pre-Op

• More delay before surgical intervention
• Ultimately worse result

Rehabilitation

Pre-Op

• Ice ➔ Swelling
• Leg Strengthening Exercises
  – Bike
  – Press
• Range of Motion Exercises
  – Flexion ≥ 130°
• Acceptance of Injury, Surgery and Rehabilitation Commitment
Technical Considerations

Operative

- Delay in Quadriceps Recovery
  Sanders; COOR 1979
  Arciero; AJSM 1996
- Incidence of Tourniquet - Induced Femoral Nerve Palsy and its Correlation with Poor Postoperative Recovery of Lower Extremity Function
  Dobner; AJSM 1982
  Krebs; Physical Therapy 1989
- Abnormal EMG Findings for Months
  Arciero, et al; AJSM 1997
  Weingarden; JAMA 1979
- “Anecdotal” Anesthesiologist View
  - Less Drugs Required
  - Easier Discharge from Outpatient

Pneumatic Tourniquet

Don’t Use or Little as Possible

- Delay in Quadriceps Recovery
  Sanders; COOR 1979
  Arciero; AJSM 1996
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Operative

“Tricks”

- Inject skin incisions with .5% Marcaine with Epinephrine
- Inject 20cc .5% Marcaine with Epinephrine into the Knee Prior to Arthroscopy
- Use Pump
- Arthroscopic Fluid Lacted Ringers (1mg epi per cc) 3cc/per 3000

Olszewski; AJSM 1999

Operative Rule #1

Need Correct Tunnel Placement

- to Restore Anatomy
- Limit Graft Stretching and/or Graft Impingement

Resulting in Loss of Motion and/or Graft Failure
Sagittal Plane

Need to Avoid Anterior Roof Impingement in Intercondylar Roof

• Flexion Contracture
• Stretching of Graft

  Howell; JBJS, 1993
  Howell; Radiology, 1991

• “Cyclops” Lesion

  Jackson; Arthroscopy, 1990

Coronal Plane

Need to be Between Tibial Eminence

• Tunnel Medial to Medial Eminence Limits Flexion

  Romano, AJSM, 1993

• Tunnel Lateral to Eminence Increase Anterior Laxity

  Muneta, Arthroscopy, 1995
Coronal Plane
Coronal Angle Greater Than 75° Caused:

- Decrease in Flexion
- Increase in Laxity
- Increased Failures

Howell, Traina, et al; AJSM, 2001

Avg. Angle 71°
(Traina In Press)

Post-Op

Femoral Nerve Block

- BTB Trend Less Pain with Better Patient Satisfaction
  
  Edekin; Clin Orthop 1999
  McCarty; AJSM 2001
  Peng; Can J Anaesth 1999
  Mulroy; Reg Anaesth Pain Med 2001
  Alford, Arthroscopy, 2003

- Hamstring Graft Not Beneficial
  
  Frost; Arthroscopy 2000

- Pain Pumps???
  - Cost vs. Benefit
Post-Op

CPM??

“Patients Like It”

- Does Not Affect Ultimate Outcome for Knee Motion
  
  Rosen et al; AJSM 1992
  Richard; Arthroscopy 1991
  Pinczewski; Knee Surg Sports Med 1993

- Beware Immediate Use with Spinal Anesthesia
  - Lawsuits (Peroneal N)

Post-Op

Ice??

Trend Less Pain, More Early Motion (Flexion)

- Patients Love It
  
  Barber; AJ Knee Surg 2000
  Barber; Arthroscopy 1998
  Ohkoshi; AJSM 1999

- Beware
Knee Immobilizer

- STG Graft Patients Do Better Without Immobilizer with Better Thigh Girth and Earlier Return to Activities
  Howell, Traina, et al; AJSM 2001
- PTP Non-braced Group Had Better Tegner Score at 6 Months Post-Op and No Difference in Stability at 24 Months Follow-up
  Moeller, et al.; Knee Surg Trauma, 2001

Physical Therapy??

- STG Grafts Showed No Difference with or Without Formal P.T. in Functional Outcome, Stability and ROM at 4 months
  Howell, Traina, et al; AJSM 2001
Formal Physical Therapy

• “Jump Starts” the Motion and Strengthening Process
  - Referrals
  - Reputation
• P.T.’s “Like It” 😊
• Patients “Like It” 😊
• Physicians Eyes and Ears
• Watch for “Dependency,” Watch for “Wound Rubbing”
• Not Absolutely Necessary for Final Outcome

Howell, Traina, et al; AJSM, 2001

Rehabilitation

Specific Hamstring Reconstruction Complaints

Not NO Morbidity, But LOWER Morbidity

• My Hamstring is Weak (85%)
  – DUH!!!
  – Gets Better—Need to Strengthen
• It is Difficult to Straighten My Knee (30%)
  – Hamstring Spasm 2° to Harvest
  – Improves by 3 Weeks
• I Heard a “Pop,” Did I Tear My Graft (25%)
  – Congratulations! You Are Working Hard
  – Adhesion Tear?
Rehabilitation

Specific Hamstring Reconstruction Complaints

• I Have Some Numbness (80%)
  – Convert to Transverse Incision (Better Cosmesis and Numbness)
  – Gets Better with Time

• What is This Discoloration on the Back of My Knee (10%)
  – “Tattooing” 2” to Hemosideria Deposit
  – Fades with Time

Rehabilitation

Good Therapist

“Makes it Fun & Motivates to Independence”
“Independent” Home Gym Program

- Bike 20 – 40 minutes
- 10 Reps/10 Sets
  - Hamstring Curl
  - Leg Press
- Stairmaster 10 – 20 minutes

Controversy

Open Kinetic Chain Extensor Strengthening vs. Closed Kinetic Chain Extensor Strengthening

**Pro Closed**
- ACL Strain Greater
  - Arms; JSM, 1984
  - Henning; AJSM, 1985
  - Yack; AJSM, 1993
- Enhancement of Function
  - Shelbourne; AJSM, 1990
  - Tippet; Oortho Phys Ther Clin
- Anterior Tibial Shear
  - Lutz; JBJS, 1993

**Pro Open**
- Better and Earlier Quad Strength
- No increase in patellar femoral pain
- No difference in stability

Morrisey, et al; Phys Ther, 2000
Bynum; AJSM, 1995
Rehabilitation

Practice One Leg Hop

- Confidence
- Strength
- Endurance

Start at 8 Weeks

Summary of Current Anterior Cruciate Ligament Injury Prevention Studies

<table>
<thead>
<tr>
<th>Study</th>
<th>Methods</th>
<th>Participants</th>
<th>Intervention</th>
<th>Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Griffis, ND, Vequist SW, Yearout KM</td>
<td>Retrospective; tracked for ten years</td>
<td>Female Division I collegiate level basketball players</td>
<td>ACL preventive program</td>
<td>87% decrease in ACL injuries following program</td>
</tr>
<tr>
<td>Caraffa, et al</td>
<td>Prospective controlled clinical trial; followed 3 years</td>
<td>680 male semiprofessional and amateur soccer players</td>
<td>20 teams participated in proprioceptive program; 20 teams normal program</td>
<td>Research group incidence 0.15 injuries/team-season control incidence, 1.15 continued</td>
</tr>
<tr>
<td>Hewett, et al</td>
<td>Prospective controlled clinical trial; followed 1 season</td>
<td>1263 subjects; 366 trained female subjects; 463 female control; 434 male control</td>
<td>6 week preseason neuromuscular training program</td>
<td>Research group incidence 0.12 injuries/athlete exposure, untrained females, 0.49/1000, untrained males, 0.09</td>
</tr>
<tr>
<td>Mandelbaum, et al</td>
<td>Prospective controlled clinical trial; followed 2 years</td>
<td>Female soccer players; numbers of subjects and controls varied each year</td>
<td>PEP neuromuscular training program</td>
<td>First year research group, 0.21/1000; untrained females, 1.17/1000</td>
</tr>
<tr>
<td>Myklebust, et al</td>
<td>Prospective controlled clinical trial; 1 year control; followed by 2 years intervention</td>
<td>2647 female team handball players</td>
<td>Control season. Balance exercises with focus on neuromuscular control, planting and landing skills</td>
<td>Control season, 0.14/1000; first season, 0.13/1000; second season, 0.09/1000</td>
</tr>
</tbody>
</table>
The Western Orthopaedics ACL Injury Prevention Training Program:

- Adapted from research conducted at Cincinnati Sports medicine and Orthopedic Center. (Sportsmetrics)
- A combination of stretching, strengthening, and jump training.
- 6 week program.

Evaluation:

- Flexibility screen.
- Analysis of running and jumping technique.
- Personalized instruction in the stretching, strengthening, and plyometric/jumping portions of the program.
- Exercise log to record progress.
### Hewett and colleagues Jump Training Program

#### Exercise Schedule

<table>
<thead>
<tr>
<th>Exercise</th>
<th>Week 1</th>
<th>Week 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Phase I: Technique</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Wall jumps</td>
<td>20 sec</td>
<td>25 sec</td>
</tr>
<tr>
<td>2. Tuck jumps</td>
<td>20 sec</td>
<td>25 sec</td>
</tr>
<tr>
<td>3. Broad jumps, stick (hold) landing</td>
<td>5 reps</td>
<td>10 reps</td>
</tr>
<tr>
<td>4. Squat jumps</td>
<td>10 sec</td>
<td>15 sec</td>
</tr>
<tr>
<td>5. Double-leg cone jumps</td>
<td>2 x 30 sec</td>
<td>2 x 30 sec(side/side and back/front)</td>
</tr>
<tr>
<td>6. 180 degree jumps</td>
<td>20 sec</td>
<td>25 sec</td>
</tr>
<tr>
<td>7. Bounding in place</td>
<td>20 sec</td>
<td>25 sec</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Exercise</th>
<th>Week 3</th>
<th>Week 4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Phase II: Fundamentals</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Wall jumps</td>
<td>30 sec</td>
<td>30 sec</td>
</tr>
<tr>
<td>2. Tuck jumps</td>
<td>30 sec</td>
<td>30 sec</td>
</tr>
<tr>
<td>3. Jump, jump, jump, vertical jump</td>
<td>5 reps</td>
<td>5 reps</td>
</tr>
<tr>
<td>4. Squat jumps</td>
<td>20 sec</td>
<td>20 sec</td>
</tr>
<tr>
<td>5. Bounding for distance</td>
<td>1 run</td>
<td>2 runs</td>
</tr>
<tr>
<td>6. Double-leg cone jumps</td>
<td>2 x 30 sec</td>
<td>2 x 30 sec(side/side and back/front)</td>
</tr>
<tr>
<td>7. Scissors jump</td>
<td>30 sec</td>
<td>30 sec</td>
</tr>
<tr>
<td>8. Hip, hop, stick landing</td>
<td>5 reps/leg</td>
<td>5 reps/leg</td>
</tr>
</tbody>
</table>
### Hewett and colleagues Jump Training Program

<table>
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<tr>
<th>Exercise</th>
<th>Week 5</th>
<th>Week 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase III: Performance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Wall jumps</td>
<td>30 sec</td>
<td>30 sec</td>
</tr>
<tr>
<td>2. Step, jump up, down, vertical</td>
<td>5 reps</td>
<td>5 reps</td>
</tr>
<tr>
<td>3. Mattress jumps</td>
<td>2 x 30 sec</td>
<td>2 x 30 sec</td>
</tr>
<tr>
<td>4. Single leg jumps, distance</td>
<td>5 reps/leg</td>
<td>5 reps/leg</td>
</tr>
<tr>
<td>5. Squat jumps</td>
<td>25 sec</td>
<td>25 sec</td>
</tr>
<tr>
<td>6. Jump into bounding</td>
<td>3 runs</td>
<td>4 runs</td>
</tr>
<tr>
<td>7. Hop, hop, stick landing</td>
<td>5 reps/leg</td>
<td>5 reps/leg</td>
</tr>
</tbody>
</table>

**Return to Play!**

- Genetics
- Motivation
- Severity of ACL Injury
- Luck?
Return to Play

Variable

- Minimum 4 months
- KT-1000 $\leq$ 3mm
- Near Normal Motion, Strength and Swelling
- Hop Index $\geq$ 85%
Return to Play

??? Brace ???

- Controversial
  - No evidence protects knee in high loads
    - Beynon, AJSM, 2003
    - Wojtys, AJSM, 1996
    - Daniel, Clin Ortho, 1989
    - Johnson, Acta Orthop Scan, 1990

- Why Use It
  - They want it
  - Psychological support
  - Proprioception

New Frontiers

Make a Low Morbidity ACL Reconstruction Procedure Better

- Contralateral STG Graft
- Allograft
Contralateral STG Grafts

- Revision ACL Surgery
- Pediatric ACL Surgery
- Shelbourne’s Experience PTB

Primary Anterior Cruciate Reconstruction Using the Contralateral Autogenous Patellar Tendon
Shelbourne, et al, AJSM, 2000

- **Contralateral Group**
  - Flexion at 1 and 2 weeks Post-op More than Ipsilateral
  - Greater Quad Strength 1, 2 and 4 Months Post-op
  - KT 1000
    - Contralateral 1.9 ± 1.3mm
    - Ipsilateral 2.2 ± 1.1mm

- **Overall Patients**
  - Pre-injury Level at 4 Months
    - 49% Contralateral
    - 12% Ipsilateral
Contralateral STG Graft ACL Reconstruction
My Best Patients!

- Selection Bias—32 Patients in 3 years
  - 27 Male 5 Female 6 Pediatric 26 Adult Patients
- KT-1000 .8mm
- Full Motion 4.5 Weeks (Extension)
- Full Activity 10 Weeks
- Release Sports 4 Months
- IKDC Score @ 9 months
  - 71% A Normal 29% B Near Normal
- No Rerupture or Graft Failures

Allograft Reconstruction Allograft Tissue

- Advantages
  - Decreased O.R. Time
  - Lack Donor Site Morbidity
  - Diminished Post-Op Pain
  - Unlimited Size
- Disadvantages
  - Cost
  - Risk of Disease Transmission
  - Osteolytic Reaction at Allograft-Host Bone Interface
    - Radiation (>2.5 MRADS)
    - Ethylene Oxide
  - Higher Failure Rate?

Gibbons, Tran Ortho Res Soc., 1984
Jackson, AJSM, 1990
Siebold, et al.; Ortho Trauma Surg., 2003
Noyes, Clinical Ortho, 1996
Schepsis, AANA, 2003
Know Your Tissue Bank!

- Office of Inspector General—44% of Tissue Banks **NOT** Accredited by American Association of Tissue Banks (AATB)
- Disasters
  - HIV 1985 & 1995
  - Sporiforms 2002
  - 56 Infections Reported by 2002
- Read
  - The Safe and Effective Use of Allograft Tissue —An Update (Current Concepts, AJSM, 2003)
    - AATB Guidelines for Tissue Procurement
    - New Sterilization Technology
    - Allograft Storage

Multicenter Randomized Prospective Study
Howell, Traina, Meade, Romano, Kaeding, Gottlieb, Freedberg

**Miami Tissue Bank**

- Posterior or Anterior Tibial Tendon
- Deep Freezing (-80°C)
- Bacteriological and Seriological Testing
- Morphological Analysis of Organs (Liver, Lymph Nodes, Lungs) Excluded 187/1000 Cases in Six Year Period
  - Buck, Clinical Orthop, 1994
- No Sterilization Treatment to Affect Strength or Stiffness of Tissue
Ultimate Failure Mode
“Strength”

Graft Type

Failure Load (N)

Stiffness

Graft Type

Failure Load (N)
Allograft Incorporation

- Cell Death
- Revascularization 4 – 6 weeks
- Cell Repopulation
- Remodeling—18 months (1 1/2 times Autograft Tissue)

Thank You