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Rehabilitation of Combined Ligament Injuries
Houston, Texas

Disclosure
• Lite-cure
• mTrigger

Objectives
• Review current trends in ACL/combined lig. rehabilitation
• Review science of ACL/PCL rehabilitation
• Arthrofibrosis Tx
• Demonstrate exercise and functional progression
• Discuss functional testing and return to play criterion

Incidence of MLI
Combination of Lig.
• Paucity of evidence for treatment
• Low incidence compared to ACL
  • ACL = .34 per 1000 person years
  • MLI = .07 per 1000 person years
• Military population = 10x ACL risk, MLI higher
• 400 ACL reconstructions = Dr. Lowe 40 MLI per year
  = 10% normal = 4%
• Sports inj. = 66%, MVA 22%
• 58% = 1 cruciate, MCL &or LCL
• 33% both cruciates & 1 collateral
• 6% both cruciates, both collaterals
• 3% both cruciates, no collaterals
• 13% mn injuries
• <5% vascular injuries
• 9% = LOM
• 6% = instability

MLI Hurdles/Outcomes
• Wound healing, arthrofibrosis, NV injuries, instability, OA (PostTOA), pain
• Difficultly in returning to pre-injury level of function
• 24 military MLI surgery = 46% unable to remain active duty, half speed sports, limitations ADLs
• Database combat-related MLI = 40% return to active duty

ACL Early (accelerated) Rehabilitation
• WBAT, ROM, Quad activation, within few days
• Outcome is superior or equivalent to delayed
• Beynnon AJSM 2005
MLI Rehabilitation Progression

- Very patient specific
- Determining factor is PCL involvement
- PCL – may hold in full extension for 3 weeks
- NWB, delayed ROM based on opinion, not tested in clinical trial.
- Owens JOrthoTrauma 2007 Immediate CPM = no adverse effect joint stability, only 12 deg. decrease in total arc of knee ROM
- PT MUST COMMUNICATE W/md = STIFFNESS

Non PCL MLI Protocol

- ROM brace locked full extension 1st week, but allow unlocked brace ROM immediately
- 30 degrees per week
- TDWB 3 wks
- Quad activation immediately using biofeedback, EMS
- Beware co-contrac. (+) HS…Quad dom.
- Increase 30 deg. Per week if no PCL
- PCL = locked 3 weeks

MLI PCL Rehabilitation

- Open chain 90 to 0 = OK.
- Closed chain squatting has HS activity
- Leg press quad dominant exercise = OK to 90 deg.

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Tibial Translation

- Open Chain near full extension = ATT
- 70 degrees = neutral
- 90 degrees = posterior translation
- Avoid active open chain quad beyond 90 degrees
Ligament Loads

- Peak Loads ACL
- Failure: ACL 1725-2160N
- PCL 4000N
- N = F req. to accelerate mass of 1KG at a rate of 1m per sec per sec.

\[ N = \frac{F \cdot m}{s^2} \]

**TABLE 8B-1**

<table>
<thead>
<tr>
<th>Activity</th>
<th>Author</th>
<th>Mean Peak Loads</th>
</tr>
</thead>
<tbody>
<tr>
<td>Squat</td>
<td>Novak and Elbehe²</td>
<td>500N (30 degrees)</td>
</tr>
<tr>
<td></td>
<td>Burescu et al³</td>
<td>1300N (19 degrees)</td>
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<td></td>
<td>Kneeland and Night³</td>
<td>250N (45 degrees)</td>
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<td></td>
<td>McCoy and Greggs⁴</td>
<td>1255N (70 degrees)</td>
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<tr>
<td>Static bicycle</td>
<td>Grooth et al⁵</td>
<td>500N (6 degrees)</td>
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<tr>
<td></td>
<td>Lent et al⁶</td>
<td>1200N (90 degrees)</td>
</tr>
<tr>
<td>Isokinetic knee extension</td>
<td>Night et al (30 degrees/60°)</td>
<td>3000N (25 degrees)</td>
</tr>
</tbody>
</table>

**Ligament loading exercises**

- Knee extension 30 to 0 degrees with resistance
- Pivoting, twisting activities - Markolf - JBJS - no protection
- Squatting - Beynnon - '97 AJSM - loads comparable to open chain - no increase in strain with increased load during squat. Knee extension = increased strain with increased load

Open Chain Peak Loads no Different Than Squat PCL

- PCL loads with rehab
- PCL = 4000N

**TABLE 8B-2**

<table>
<thead>
<tr>
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<th>Author</th>
<th>Mean Peak Loads</th>
</tr>
</thead>
<tbody>
<tr>
<td>Squat</td>
<td>Beynnon et al⁷</td>
<td>1300N (0 degrees)</td>
</tr>
<tr>
<td></td>
<td>Burescu et al³</td>
<td>1500N (60 degrees)</td>
</tr>
<tr>
<td></td>
<td>Lent et al⁶</td>
<td>500N (90 degrees)</td>
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<tr>
<td></td>
<td>Night et al (30 degrees)</td>
<td>1200N (90 degrees)</td>
</tr>
<tr>
<td></td>
<td>McCoy and Greggs⁴</td>
<td>1600N (94 degrees)</td>
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<tr>
<td>Leg press</td>
<td>Lent et al⁶</td>
<td>1750N (90 degrees)</td>
</tr>
<tr>
<td>Knee extension</td>
<td>Lent et al⁶</td>
<td>1000N (90 degrees)</td>
</tr>
<tr>
<td>Knee flexion</td>
<td>Lent et al⁶</td>
<td>1700N (90 degrees)</td>
</tr>
</tbody>
</table>

Incidence of ACL Tears NCAA

- Dragoo AJSM 2012
- Artificial turf = 1.4 x higher than grass
- Players 10x more likely to tear ACL during game than practice
- Scrimmages resulted in greater injury than regular practice

ACL: Return to Play American Football Collegiate and HS Level

- McCollough AJSM 2012
- 65% able to return
- Subjective questionnaire:
  - 43% able to resume pre-injury level
  - 27% returned, but lower level
  - 30% unable to return (67% other interests 50% feared re-injury)
- 165 players

**Return to Sports 1 year Factors**

- Lentz AJSM 2015
- ACL return to sports: fear factor, quad function, other
- 1 year s/p ACL 73 pts. 46 YRTS 27 NRTS 13 NRTS – other 14 NRTS – Fear confidence Quad weakness assoc. with NRTS – Fear, lack of confidence
**NFL ACL injuries return to play**

- Shah, Andrews AJSM 2010
- 63% returned to play 10.8 mos. After reconstruction
- High draft pick (4th round or higher)
- Greater than 4 years of play in NFL
- Greater odds to RTP

**Trend is all functional rehabilitation**

Don’t forget to strengthen!

- Quad weakness may be masked with functional rehabilitation exercise
- Return to sports develops PF pain, tendonopathy, effusion
- Don’t drop strengthening

**Phase I ACL Rehab. ROM and Strength**

- ACL/MCL injury on December 24, 2011
- Grade III MCL
- Surgery: Dec. 30, 2011 Dr. Andrews
- Returned to Houston for rehab on January 10

**MLI Outcome**

- Return to preinjury level is UNCOMMON
  - 40% nearly Normal
  - 40% Abnormal
  - 20% severely abnormal
- Shaun Livingston ½ years after ACL/PCL/MCL/lateral meniscus/patellar dislocation

**MLI (ACL,MCL) Rehabilitation**

Adrian Peterson NFL Running Back

- NFL MVP 2012
- 2,097 yds.
- 6th fastest player to reach 8,000 rushing yards
- 150 yds. 7 games
- ACL PTG, MCLIII, 8 mos prior to begin of season
- Joint condition/intensity parents - genetics

**ACL/MCL Combined ligament injury**

- Limits ROM and WB 1st 4-6 weeks
- Locked in extension for 2 weeks, increased flexion 30d per week
- WB with crutches gradual increase, D/C crutches 4-6 weeks
Motion Complications

- Increasing flexion
- Restricted flexion = increased PF Compression
- Flexionator
- Provides hydraulic resistance
- 5 min. on 5 min. off, repeat
- 6 x per day
- HS Biofeedback Prone Hangs

Anterior Pain With Forced Extension

- Cyclops lesion
- Anterior nodular tissue anterior to ligament
- Anterior arthrofibrosis
- Define location of discomfort?

Infrapatellar Fat Pad
Superior Glide Quad Inhibited Patient!

- Source of pain post-op ACL
- ATS portals pass through fat pad
- Cause fibrotic hematoma in some patients
- May affect p. tracking with ATS
- Early intervention = US/Laser/manual soft tissue release, scar mobilization, normal quad function = no contracture

Steps To Avoid Extension LOM with quad inhibition/splinting

- Recognize early factors:
  - Poor quad function – no SLR
  - Flexed knee ambulation
  - Poor pain tolerance
  - MCL/Meniscus repair
- Reversing Lack of Extension
  - 1 cm = 1° HHD Daniel AJSM ’89

Biofeedback mTrigger

mTrigger Biofeedback
**Effects of Flexion Contracture**
Paulos AJSM 1987 IPCS

- Increased PF compression
- Pressure necrosis to articular cartilage
- Stimulates improper gait pattern
- Promotes patella infera

**Causes of Decreased Flexion**

- Loss of Capsular recesses – medial and lateral gutter of knee
- Loss of suprapatellar pouch
- Medial scarring due to MCL bleeding

**Progression after Motion Loss**

- Most likely will have articular cartilage lesions
- Pressure necrosis, shearing of soft ac during rehabilitation

**Post operative Release Rehab.**

- Portable continuous epidural – helpful
- Educate patient – window of opportunity
- CPM, Flexionator
- Muscle relaxants, antidepressants

**Early Motion Salter’93 Cyclic Compression**

- Decreases/prevents adhesions
- Adhesions = increased compression of P-F due to tethering effect
- Allows nutrition for matrix

**Laser Therapy**

- Use all modalities, US, topical anti-inflammatory cream
**Compression & Fluid Flow**

**Matrix CPM**

- As compression increases, resistance to fluid flow in matrix increases
- GAG's slow down fluid flow in & out of matrix
- Result = increased stiffness of cartilage
- Stiffness = allows resistance to compression
- **Status of articular cartilage determinant for return to activity**

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**Pre op and Immediate Post op Training**

- Quad Re-cruiitment biofeedback 10'
- Stimulate Proprioception - (gait training, balancing activities) cone amb.
- Extension ROM techniques
- **SLR's up to 100°**
- Flexion contracture = locate pain
- Ant. Or Post.
- Ant = fat pad impingement
- Post = capsular scarring or bursa spasm

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**Gait Abnormalities**

**Acute ACL Tears**

- Decreased NM input
- Delayed quad firing – heel strike
- Result = flexed knee gait pattern
- Increased PFJRF
- Force patient to squeeze quad at heel strike
- Treadmill amb.

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**Step 2**

**Begin Gradual Loading Exercises**

**Leg Press Best minimal HS**

- MR functional squat – supine squat low load high endurance activity 60 second contractions
- Begin with 5Kg
- Wilk AJSM – **leg press = highest EMG = 85 degrees**

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**Step 3**

**Body Weight Control Functional Squat Posture**

- MR Systems Squat Control
- Chair Squats 3x20 D & SL
- Speed Squats 20 sec. 5 sets
- Technique = chest toward ceiling on way up

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**Chris Powers JOSPT 2003**

- Controlling femoral position
- Hip ABDuctor, G.Max, Lateral Rotation,
- NWB routine
- Hewitt AJSM ’07 – pelvic control - ACL
Powers: Controlling Hip Internal Rotation, Knee Adducton

- WB routine
- ABD, GMAX, Lateral rotation

Core Strengthening Strengthens Kinetic Chain

- Rotational plyoball: hold VMO contraction
- Lower Abdominal Trunk flexion/extension using Swiss Ball
- Hewitt AJSM '07 - Core control may be assoc. with ACL tear = pelvic control = kinetic chain = PF control

Hip Flexor Stretch/Strengthening

- Loss of proprioception after ACL rupture
- Roberts et al, J Orthop Res, 2000
- Loss of proprioception after ACL reconstruction

Hewitt AJSM '07 - Core control may be assoc. with ACL tear = pelvic control = kinetic chain = PF control

Proprioception

- Loss of proprioception after ACL rupture
- Roberts et al, J Orthop Res, 2000
- Loss of proprioception after ACL reconstruction

Cruciate Tear Loss of Proprioceptive Function must be Restored before return to sports

- Primary goal – Rehabilitation
- Enhance muscle reaction time
- Stabilization/Recruitment

High Speed Biodex

- Speeds 180-300 deg./sec.
- PCL, Quad only program, combined Q/HS @ 6 mos
- May stimulate NM control
- Rapid reversal from ext./flexion
- HS curls, good mornings
When to Run?

- ACL PTG 2 ½ - 3 mos. Treadmill
- Allograft ACL 3-4 mos.
- MLI = 4-5 mos
- MLI timeframes dependent on quad strength and symptoms, # of lig.

Phase II Functional Strengthening

Runners Pose

Cone Reach

Phase III Plyometrics after 4 weeks of Running

- Plyometrics Develop:
  - Strength
  - Speed
  - Power
- Good Proprioceptive Training
- Injury Prevention
- Not everyone needs to jump!

Plyometrics

- Jumps
  - 2 footed landing
- Hops
  - 1 foot landing
- Bounds
  - Jumping form one foot to the other
- Proprioceptive
Quad Re-education
Take Off

- Recruitment = plyometric routine, single leg plyo’s
- Sportsmetric
- Functional Drills
- Isokinetic strength, leg press 90-40

Bilateral Cone Hop Stick

Broad Jumps

Male Broad Jump
Progression to Single Leg Hop

- Maintain mechanics
- Must undergo double leg jumps
- Must have adequate core/quad control

Phase IV Agilities/Sports Specific

- The ability to change direction rapidly without loss of body control
- Uses

Combination Core/LE/UE Slide Board End Stage Rehab

Most Functional Tests: Quad Function Acceleration no Deceleration

- Jump tests, running, pivoting tests require minimum deceleration
- Quad functions most heavily during deceleration
- “Brakes” are vital to function

Functional Assessment

50n High School FB Paine, Chicas, Bailey, Harari

- Skilled vs Non-skilled positions
- Skilled demonstrated strong correlation ($r = .70$) 60d isokinetic & SLBJ
- Non-skilled low correlation ($r = .30$) 60d isokinetic & SLBJ

<table>
<thead>
<tr>
<th>Correlation</th>
<th>40-yd Shuttle</th>
<th>SLBJ D</th>
<th>SLBJ ND</th>
<th>VJ D</th>
<th>VJ ND</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flexion dominant</td>
<td>-0.067</td>
<td>0.262</td>
<td>0.303</td>
<td>-0.021</td>
<td>0.053</td>
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<tr>
<td>Extension dominant</td>
<td>-0.396</td>
<td>0.700</td>
<td>0.600</td>
<td>0.234</td>
<td>0.368</td>
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<tr>
<td>Flexion non-dominant</td>
<td>-0.125</td>
<td>0.310</td>
<td>0.282</td>
<td>0.247</td>
<td>0.207</td>
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<tr>
<td>Extension non-dominant</td>
<td>-0.216</td>
<td>0.524</td>
<td>0.442</td>
<td>0.244</td>
<td>0.235</td>
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<tr>
<td>SLBJ Average dominant</td>
<td>-0.608</td>
<td>0.438</td>
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<tr>
<td>SLBJ Average non-dominant</td>
<td>-0.484</td>
<td>0.617</td>
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</tbody>
</table>

Fig. of eight 40 yd. run 9.5s Paine et al IJSPT Nov 2015
Conclusions: Functional Testing HS Football Players

- Skilled versus Non-skilled positions will have effect on strength to function correlations
- Body type has an effect on functional performance during function testing

Return to Play Objective Measures
Y Bal SL Squat reach

SL Hop for Distance

ACL follow up Day

- Tracking post-op patient rehabilitation is critical to successful outcome.
- Each patient is objectively measured
- Y Balance

James Cooper, Eric Sugarman

- Functional Exercise
- Must have adequate strength

ROM, HHD, YBal, Isom., SLBJ
Return to full competition in NFL
8 mos

- Timetables were not unusual
- Level of play was very unusual
- Skill position, ability to cut/pivot with no fear – superhuman effort

MLI Rehab Conclusions

- Rehabilitation = team effort
- Must know healing constraints PCL involvement?
- Progression = ROM/strength, proprioception/balance, plyometrics/agilities
- Critical to recognize early arthrofibrosis – keep MD updated!
- Never progress patient until ready for next phase

PCL, PL Corner

- PL corner, FCL
- LaPrade technique restoring FCL, popliteus tendon, popliteofibular ligament