Shoreline Orthopaedics

Bruce A. Stewart, MD, MBA
Orthopaedic Surgeon/Sports Medicine Specialist
Holland ~ Hudsonville ~ Zeeland
P 616.396.5855

Primary Surgery: ACL Reconstruction

Secondary Surgery (if applicable): Meniscal repair, meniscectomy, microfracture, chondroplasty, MCL injury, posterior lateral corner injury, lateral external-articular tenodesis
Outcome Measures: ACL-RSI

Operational Definitions:

Phase Goals: Primary impairments targeted during a particular phase
Milestones: Minimum objective criteria required to progress to the next phase of rehab
Full Knee Extension Range of Motion (ROM): Aim for symmetrical to uninvolved limb
Limb Symmetry Index (LSI): relative performance compared to non-surgical side
Torque to Bodyweight (BW) Ratio: absolute strength one should be at based on height and size

- Equation for Torque to BW Ratio: Force (Newtons) x shin length (meters)/bodyweight (kilograms)

Appendices:

Secondary Surgery or Graft Considerations (appendix 1)
Non-Weight Bearing Quadricep Strengthening Exercise Progression (appendix 2)
How to Measure Dynamometer Leg Strength (appendix 3)
Return to Jog Testing Checklist (appendix 4)
Loading Tolerance Guidelines: To assess response to loading (appendix 5)
Return to Practice Progression (appendix 6)
Return to Sport (RTS) Testing Checklist (appendix 7)

Pre-Operative Rehabilitation
Phase Goals: Get at least one pre-op visit in as soon as possible after injury to measure pre-operative strength and range of motion numbers before uninvolved leg becomes deconditioned. **Must Have Before Surgery:** - Complete Pre-Operative Testing - Full AROM and PROM knee extension - Knee flexion ≤10° of uninvolved limb (outside of subsequent meniscal tear that prevents flexion or extension ROM) - Straight Leg Raise with no extension lag **Good Goals Before surgery** - Quadriceps, Hamstring, and Hip Abduction LSI ≥70%   o Keep values for after surgery to use as reference values and goal markers - Trace to zero effusion - Restore normal gait pattern
Patient Education: - Importance of meeting goals before surgery to improve post-surgical outcomes - Home Exercise Program for before surgery and immediately after surgery until first physical therapy appointment (0-72 hours) - General idea of post-operative rehabilitation and return to activity timeline

<table>
<tr><th colspan="3">Post-Op Phase 1 (Week 1)</th></tr>
<tr><td colspan="2">Phase Goals:
– Reduce swelling
– Stimulate quad activation
– Decrease Pain
– Gait Training
– Improve ROM
– Return knee to homeostasis</td><td>Milestones:
– ROM: 0-90
– Straight Leg Raise without extension lag
– Discharge brace if in immobilizer (non-hinge brace) after 1 week if able</td></tr>
<tr><td colspan="3">Treatment Ideas</td></tr>
<tr><td rowspan="6"></td><td>Range of Motion</td><td><u>Flexion AROM</u>: heel slides, bike rocking on stationary bike, wall slides

<u>Extension AROM</u>: quad set with assisted heel pop, if necessary, calf stretch, prolonged stretch

<u>Flexion/Extension PROM</u>: prolonged low load stretching</td></tr>
<tr><td>Muscle Performance/Strength</td><td><u>Open Kinetic Chain</u>: quad sets, straight leg raises (with assist to keep straight leg if necessary), long arc quad (0-90)

<u>Closed Kinetic Chain:</u> weight shifting, mini squat, marching, step and hold</td></tr>
<tr><td>Manual Therapy</td><td>PROM flexion/extension, patellar mobilizations, effleurage around knee joint, soft tissue mobilizations to surrounding tissues to aid in knee ROM</td></tr>
<tr><td>Modalities</td><td><u>Electric Stimulation:</u> NMES to quadriceps

<u>Ice:</u> 3-4 times per day

<u>Compression</u>: ACE wrap or compression sleeve</td></tr>
<tr><td>Gait Training</td><td>Walking with UE support to aid in good quadriceps contraction and proper gait mechanics</td></tr>
<tr><td colspan="2">Home Exercise Program Consideration:
Quad set: 80-100x per day with assist as needed to obtain heel pop
LAQ: 30x5 second hold
Heel slides: 30x5 second hold
SLR (assist as needed): x30
Self-mobilization of patella: x20-30 each direction</td></tr>
</table>

<table>
<tr><td colspan="3">Post-op Phase 2 (Week 2-3)</td></tr>
<tr><td colspan="2">Phase Goals:
– Continue to improve ROM and quad activation
– Gait training (normalize gait)
– Minimize swelling
– Discharge brace</td><td>Milestones:
– ROM: 0-115 (aim for some extension past 0)
– Knee joint circumference: ≤1.5cm difference then opposite knee
– Walking without crutches
○ Criteria for discharge:
▪ 10 straight leg raise with no extension lag
▪ 10 slow marches with full TKE</td></tr>
<tr><td colspan="3">Treatment Ideas</td></tr>
<tr><td rowspan="7"></td><td>Range of Motion</td><td>Continue from previous phase</td></tr>
<tr><td>Muscle Performance/Strength</td><td><u>Open Kinetic Chain</u>: short arc quad (0-45), long arc quad (0-90), multi-angled isometrics for quads and hamstrings, hamstring curls (use progressive resistance through bands/weights/manual pressure, etc.)

<u>Closed Kinetic Chain:</u> wall sits, squats, leg press

<u>Accessory Training:</u> hip, core, and calf strengthening

**perform strength training with blood flow restriction (BFR) cuffs if available</td></tr>
<tr><td>Manual Therapy</td><td>Same as previous phase. Incorporate incision mobilizations if incisions have fully healed</td></tr>
<tr><td>Gait Training/Neuromuscular Re-education</td><td>Weight shifting, single leg balance, backward walking, marching, step and hold, stair ambulation training
- cue landing on bent knee and squeezing quad during stance phase

**consider using functional NMES if decreased quad control</td></tr>
<tr><td>Modalities</td><td><u>Electric Stimulation:</u> NMES to quadriceps

<u>Ice:</u> 3-4 times per day, instructing to ice right before therapy session

<u>Compression</u>: ACE wrap or compression sleeve</td></tr>
<tr><td>Aerobic Conditioning</td><td>Bike, Upper body conditioning</td></tr>
<tr><td colspan="2">Home Exercise Program Consideration:
Education to keep pain ≤5/10 pain or below
Same as previous phase</td></tr>
</table>

Post-Op Phase 3 (Week 4-6)		
Phase goals: – Restore ROM – Progress Foundational Strength Training – Normal ADLs – Gait normalized	**Milestones**: – Flexion ROM within 5-10° of other side – Can ambulate for at least 15 minutes with no pain – Reciprocal Stair Ambulation – Knee joint circumference: ≤0.5cm difference	
Treatment Ideas:		
	Range of Motion	PRN for any continued knee mobility deficits
	Muscle Performance/Strength	Open Kinetic Chain: continued progressive overload of quadriceps and hamstrings (SAQ, LAQ, hamstring curls, etc), hip abduction Closed Kinetic Chain: squats, deadlifts, wall sit, step up/down, lunges, bridges, hip thrust Accessory Training: hip, core, and calf strengthening **perform strength training with blood flow restriction (BFR) cuffs if available **progressive overload through weight, tempo, introduce asymmetries (DL-->split stance-->SL), faster tempo, more time under tension, etc.
	Neuromuscular Re-Education	Dual task training during exercise (add cognitive component), single leg stance on viable surface, introduce perturbations, standing glut med isometric
	Manual Therapy	PRN for any continued knee mobility deficits
	Modalities	PRN for pain and effusion or continued decreased quad control
	Aerobic Conditioning	Bike, elliptical, stair master (at least 15 minutes, 2-3x/week)
	Home Exercise Program Consideration	SLR with resistance LAQ with resistance Prone quad stretch Single leg squat eccentrics Step ups Heel raises Flexibility Suggest gym membership if able to use bike, elliptical, perform HEP with resistance, etc.

<table>
<tr><td colspan="3">Post-Op Phase 4 (Week 7-9)</td></tr>
<tr><td colspan="2">Phase Goals:
– Increase loading capacity
– Increase movement competency and variability
– Prepare body for jogging</td><td>Milestones:
– Full ROM flexion and extension</td></tr>
<tr><td rowspan="5"></td><td>Muscle Performance/Strength</td><td>Continued from previous phase with progressive overload. Start to add in force absorption and quicker tempo exercises (depth drop, pogo progression, snap downs, etc)</td></tr>
<tr><td>Neuromuscular Re-Education</td><td>Progress perturbation training and higher-level balance progressions (incorporate sport-specific tasks as appropriate). Higher-level multi-task cognitive training</td></tr>
<tr><td>Aerobic Training</td><td>Progress in intensity and duration</td></tr>
<tr><td>Gait Training/Modalities</td><td>PRN as needed for continued deficits</td></tr>
<tr><td>Home Exercise Program Consideration</td><td>Resisted squats, step ups, RDLs
Single leg squats
Heavy resisted LAQ
Unilateral heel raises
Aerobic Training</td></tr>
</table>

<table>
<tr><td colspan="3">Post-Op Phase 5 (Week 10-15)</td></tr>
<tr><td colspan="2">Phase Goals:
– Increase lower extremity strength
– Pre-plyometric --> light plyometrics
– Initiate jogging
– Start to transition care to a bridge program or ATC/strength coach if appropriate</td><td>Milestones:
– Pass return to jog testing (appendix 4)
  ○ 3 months minimum
– ≤3/10 pain consistently and no swelling with jogging
– 60% Quadriceps LSI @ 12 weeks (appendix 3)</td></tr>
<tr><td colspan="3">Treatment Ideas:</td></tr>
<tr><td rowspan="4"></td><td>Muscle Performance/Strength</td><td>Continued progressive overload and exercises in previous phase
Start to initiate light plyometrics (broad jump, jump rope, etc.) at 50 foot contacts/session</td></tr>
<tr><td>Neuromuscular Re-Education</td><td>Controlled landing mechanics and higher-level balance (both reactionary and anticipation), incorporating sport as able and appropriate</td></tr>
<tr><td>Aerobic Training</td><td>Continue cross training, return to jog program</td></tr>
<tr><td>Home Exercise Program Consideration</td><td>Continue from previous phase</td></tr>
</table>

<table>
<tr><th colspan="3">Post-Op Phase 6 (month 4-6)</th></tr>
<tr><td colspan="2">Phase Goals:
– Initiate sprinting
– Increase plyometric capacity
– Initiate agility
– Continue care with bridge program/ATC/strength coach if appropriate
– Perform RTS testing for first time (around 6 months)</td><td>Milestones:
– Quadricep LSI symmetry: ≥60-70%
– Quadricep Torque/BW ratio %: ≥75% bilaterally
– Hamstring and Glut LSI symmetry: ≥ 90%
– ACL-RSI: ≥60%
– Hop testing: ≥80-85%</td></tr>
<tr><td rowspan="3"></td><td>Muscle Performance</td><td>Progressive overload of lower extremity (65-85% 1RM)
Heavy barbell squats and deadlifts, nordic hamstrings, KB swings, sled work
Core stability exercises (anti-flexion, anti-extension, anti-rotational)</td></tr>
<tr><td>Aerobic Training</td><td>Circuit training
Increase duration and intensity of running
Cross training</td></tr>
<tr><td>Plyometric Training</td><td>Box jumps, drop jumps, broad jumps, medicine ball progressions (progressing to perform in multiple planes of motion)

Progress volume by increasing foot contacts by 50 every 3 weeks until 250 foot contacts/session is achieved</td></tr>
</table>

<table>
<tr><th colspan="3">Post-Op Phase 7 (Month 6-9)</th></tr>
<tr><td colspan="2">Phase Goals:
– Start to gradually re-incorporate back into practice (around month 8)
– Restore conditioning to pre-injury level
– Restore strength to pre-injury level
– Perform RTS Testing (9 months) and possible discharge if passed
    o If not passed, continue to re-test patient 1x per month until passed</td><td>Milestones:
– Quadriceps Strength LSI: 70-80%
    o 85+% after 9 months
– Hamstring, and Glut Strength LSI: ≥95-100%
– Quadricep Torque/BW ratio: 2.5 for females, 3.0 for males
– ACL-RSI: ≥80%
– Hop testing: ≥90%</td></tr>
<tr><td rowspan="4"></td><td>Muscle Performance/Plyometric Training</td><td>Max effort and high intensity strength and power training

Around 200-250 foot contacts/session</td></tr>
<tr><td>Sport Specific Training</td><td>Individualize to sport and position, incorporate sport situations and how they got injured if in sport
Phase them back into practice</td></tr>
<tr><td>Agility Training</td><td>Up to 100% intensity, reactionary, unpredictable</td></tr>
<tr><td>Aerobic Training</td><td>Circuit training, max effort sprinting, cross training, running progressions
**replicate aerobic/anaerobic training demands of their sport or activity</td></tr>
</table>

	Home Exercise Program Consideration	Give exercises that would replicate and get patient ready for RTS testing. If patient fails RTS testing, give specific exercises to work on parts they failed to perform until the next testing.

Appendix 1- Secondary Surgery or Graft Considerations

Procedure	Rehab Consideration
Quadriceps Tendon Autograft	- Slower to regain quadriceps strength compared to other grafts - Train quadriceps in multiple angles of hip flexion/extension to fully work rectus femoris
Bone-Patellar-Bone (BTB) Autograft	- Be aware of patellofemoral forces with possible irritation during loading. Address early with tendinopathy protocols (isometrics, progressive loading exercises, etc) - Treat anterior knee pain as needed with taping, e-stim, manual therapy, loading modifications
Hamstring Tendon Autograft	- Begin isometric knee flexion @ 6 weeks - Begin isotonic knee flexion @ 8 weeks - Delay plyometrics until 16 weeks - Hamstring LSI will progress more slowly o Use Quadriceps LSI biomarkers in protocol as references for hamstring LSI
Allograft	- Slower healing and graft incorporation which means slower progression to higher intensity activity - No weighted OKC exercises for 12 weeks - 12-month RTS timeline
Meniscus Repair	- Simple Repair o WBAT, 0-100 degrees for first 6 weeks o Resume normal ACL protocol after 12 weeks o Delay isolated hamstring strengthening for 8 weeks - Complex Repair o NWB in extension locked brace for 6 weeks o ROM 0-100° for first 6 weeks, then progress as tolerated after o Delay isolated hamstring strengthening for first 12 weeks o Will likely delay return to jogging until 4 months o Resume normal ACL protocol after 16 weeks o No loaded squats below 90° for 6 months, can use 0-45°, 0-75°, 0-90° progression once weightbearing o No pivoting or twisting for 6 months

	○ Seated quad isotonic and isometrics at multiple angles can replace for weight bearing exercises during NWB phase
Lateral Extra-Articular Tenodesis	- Use primary ACL protocol as guide for progression - WBAT in brace for 4 weeks - ROM as tolerated - Begin bike at 3 weeks - May have more pain during flexion range of motion inhibiting progression
Posterolateral Corner Repair	- NWB in brace for 6 weeks - 0-90° for 4 weeks - Minimize external rotation and varus torques for first 6 weeks
MCL injury	- Restrict motion to sagittal plane for 4-6 weeks to allow MCL to heal - Perform exercises with slight tibial internal rotation to put less stress on MCL - Consider brace if patient has pain limiting function If patient had MCL repair: - Immobilizer locked in extension for 2 weeks - Avoid valgus stress or OKC for 6 weeks - Work adductors in more functional position or with resistance point above the knee (make short lever position)
ACL Revision	- Direct rehab under original ACL protocol
Chondral Repair	- Dr. Stewart will direct restrictions depending on procedure done
Microfracture	- NWB for 8 weeks, resume normal ACL protocol at phase 2 after that

Appendix 2- Sample Recommendation for Quadricep Strengthening for NWB Duration

Exercises performed 0-90°	
Week 0-2	LAQ: no/manual/light resistance, 2-3x12-15, 3-1-3 tempo
Week 2-4	LAQ/knee extension machine: moderate weight, 2-3x8-12, 3-1-3 tempo
Week 4-6	LAQ/knee extension machine: heavy weight, 3-4x4-6, 3-1-3 tempo
Recommend addition of using Blood Flow Restriction while performing exercises starting at 2 weeks	
Progress weight and exercise based on patient response (aim for 5-7/10 RPE level)	

Appendix 3- Measuring Dynamometer Strength

Muscle Group	**Testing Standard**
Knee Extension	Handheld dynamometer with fixation from cuff/strap around patient ankle. Patient seated and knee at 60 degrees flexion. Maximal voluntary contraction for 3 seconds.
Knee Flexion	Handheld dynamometer with fixation from cuff/strap around patient ankle. Patient seated and knee at 90 degrees flexion. Maximal voluntary contraction for 3 seconds.

Hip Abduction	Handheld dynamometer with fixation from cuff/strap, patient side lying and top leg in 20-30 degrees abduction and slight extension and anchor around table. Maximal voluntary contraction for 3 seconds.

Appendix 4 – Return to Jogging Testing Checklist

☐ 1.4 Nm/kg Peak Quadricep Torque to BW ratio
☐ 60% Quadriceps LSI
☐ 90% LSI for 30 second SL pogo test
☐ 6” Anterior step-down test for 30 seconds LSI (pass/fail based on kinematics)

Appendix 5 – Load Response Guidelines

Color Light	**Definition in Symptoms**	**Interpretation**
Green	Minimal soreness (workout sore), no pain, any symptoms resolve within 24 hours	Responded well, progress as appropriate
Yellow	Moderate soreness, mild pain, symptoms resolve within 48 hours	Stay at current level for a couple more treatment session to see if response changes at all
Red	Sharp pain, pain increases with more repetitions, increased swelling, symptoms last >48 hours	Regress exercise parameters

Appendix 6 – Return to Play progression (starting month 8)

Level of Participation	**Description**
Non-contact drills	Structured drills where movement is known and anticipated
Non-contact Full Practice	Can participate in drills where movement is more unpredictable (i.e. possession drill or small sided game)
Contact Drills (once passed RTS testing)	Can participate in drills where some contact is known and anticipated (i.e. 1v1 drills)
Contact Full Practice	Full participant in all phases of practice both predictable and unpredictable (game like situations)
Return to Game Workload Restriction	Limited minutes with gradual build up based on Load Response Guidelines
Return to Game No Restriction	Full participation no restrictions
- If setback occurs (red light), then regress back to previous phase	

Appendix 7- Return to Sport Testing Checklist

☐	95% Quadriceps LSI @ 60 degrees knee flexion
☐	95% Hamstring LSI @ 90 degrees knee flexion
☐	Peak Quadricep Torque to BW ratio (Nm/kg) 2.5 for females, 3.0 for males
☐	90% LSI Hop Testing: SL Broad jump, SL Crossover Triple Hop, SL Vertical Jump, Medial Hop Test for 30 seconds
☐	80% ACL-RSI
☐	300-yard shuttle test time (60s for males, 70s for females)
☐	Pro Agility Test: Both 90% LSI and within 5.1 seconds for males, 5.3 seconds for females)
☐	90% LSI Muscle Endurance Testing: rear foot elevated split squat for max reps in 30 seconds at 50% body weight, lateral lunge to bench for max reps in 30 seconds at 25% body weight