Anterior Cruciate Ligament Reconstruction Protocol

The anterior cruciate ligament, or ACL, is one of the major stabilizing ligaments in the knee joint. Damage to this ligament commonly results in "giving way" or buckling of the knee and a progressive loss of function. Surgical reconstruction of the ACL is usually required in order to restore normal function.

When the ACL is reconstructed using a patellar tendon autograft, the middle one third of the patellar tendon is harvested along with a "plug" of bone from the tibia and patella. The resultant bone-tendon-bone graft is placed such that one bone plug is inserted in the femoral tunnel and one in the tibial tunnel. Both bone plugs are usually secured with a screw in each tunnel. Patients with patellar tendon grafts may have more anterior knee pain due to the trauma to the extensor mechanism. Therefore, aggressive resisted knee extension exercises are usually delayed for the first 6 – 8 weeks.

When the ACL is reconstructed using a hamstring autograft, a strip of the semitendinosis and gracilis tendons is harvested. The tendons are doubled over such that the resultant graft consists of 4 strands. The graft is then secured in the femoral tunnel using the bone mulch screw system and in the tibial tunnel with the washerloc system. Patients with hamstring grafts may have more posterior knee pain where the graft was harvested. Therefore, aggressive resisted knee flexion exercises (e.g. hamstring curls) are usually delayed for the first 6 weeks. (Carofino 2005, Ristanis 2009)

Physicians may adjust the timeline of the protocol for pediatric patients due to higher likelihood of re-tear. Common adjustments include prolonging running to 6 months, cutting to 9 months, and return to sport 12 months. Please consult the surgeon for their preferences on progression.

Pre-Op Protocol

1. Briefly explain the surgery using the knee model.
2. Review and issue ACL Patient Information Packet emphasizing pre- and post-op goals and expectations.
3. Review pre- and post-op exercises, and issue a comprehensive home exercise program.
4. Schedule first post-op visit.

Post-Op Protocol

Phase I (0-6 weeks): *Period of Protection*

0 - 4 Days

- **Full passive extension immediately post-op.**
- ROM 0-90 degrees.
- CPM at home –at discretion of MD. Current systematic reviews have not supported the routine use of CPM for isolated ACL reconstructions (Lobb 2012, van Grinsven 2010) .

Suggested Interventions:

1. Gait training: ambulate WBAT with 2 crutches unless otherwise instructed by the physician.
2. Begin SLR's , quad sets, ankle pumps, and heel props to regain extension in the hospital -if possible. Do not perform straight leg raises if extension lag is present.

- Promote full extension- do not allow leg to rotate outward or place a pillow under the knee to allow it to stay bent.
- Use ice and elevation to decrease pain and swelling (5x/day) – knee higher than level of the heart, ankle higher than the knee.

5 Days - 2 Weeks

- Emphasize full passive extension/hyperextension equal to uninvolved knee unless $\geq 5^{O}$ of hyperextension- heel props, prone hang. (Wilk et al 2012).
- ROM 0-110 degrees until sutures removed, then flexion to tolerance.
- Progress to FWB as soon as patient achieves adequate quad control (e.g. able to ambulate without flexed-knee gait and no increase in effusion).
- If issued CPM, typically discontinue after first post-op MD appointment (~ 10 days), if 90 degrees flexion achieved.

Suggested Interventions:

1. Gait training with assistive device (as appropriate). Patient must demonstrate smooth heel toe pattern with 2 crutches prior to weaning to one crutch, then eventually to no device.
2. Electrical stimulation to facilitate volitional quad control (Snyder-Mackler 1991, Hauger 2018).
3. Patella mobilization. Instruct patient in self-mobilization technique with emphasis on superior glide and scar tissue massage as incision heals.
4. Multi-angle isometrics for quads ($\geq 60^{O}$ knee flexion) and hamstrings.
5. AA/AROM exercises to increase flexion (e.g. knee flexed over table edge with support of opposite leg, supine wall slides, etc.).
6. Leg press (0- 45 degrees) at low resistance and calf raise exercises on leg press machine.
7. 4 way SLR's with weight of leg only. Add weight as tolerated only if full knee extension is maintained.
8. Hamstring curls with added weights as tolerated. Hold until after 6 weeks if hamstring autograft was used.
9. Partial squats (0-45 degrees) with hip hinge to encourage hamstring activation and decrease stress on graft (Escamilla 2012).
10. Anterior and lateral weight shifting (0-45 degrees) to encourage muscle activation and balance.
11. Calf raises.
12. Hamstring and calf stretching, but avoid aggressive hamstring stretching if hamstring autograft has been used.

2 - 6 Weeks

- **Effusion should be $\leq$3 cm (at mid-patella) by 2 weeks.**
- Continue to emphasize full knee extension and control of effusion.
- ROM to tolerance (flexion should be $\geq 120^{O}$).
- **Gait should be normalized by 6 weeks.**

Suggested Interventions:

1. Continue with aggressive patellar mobilizations and scar tissue massage.
2. Stationary bike for ROM. May begin exercise program if effusion is controlled.
3. Lateral step-ups/downs beginning at 2" and progressing height only if proper technique is maintained - i.e. no hip substitution, good control of arch (Ernst 2000).
4. Closed kinetic chain (CKC) terminal knee extensions standing with theraband /cable column resistance with band proximal to knee joint line (may begin sooner if patient is FWB).
5. Retro-ambulation to facilitate quad control and dynamic extension.
6. Rocker board for static balance with two-leg stance (may begin sooner if patient is FWB).
7. Hamstring curls on isotonic machine. Delay until 6 weeks if hamstring autograft.
8. Continue with squats (progressing from double-leg to single-leg as tolerated), emphasizing lower ranges (e.g. 60-90^{O} of knee flexion) and proper technique (e.g. knees behind toes, hip hinge, control of valgus).
9. Leg Press (0-60 degrees), add resistance and move to single leg as control improves.
10. Multi-hip machine.
11. Static single-leg balance on floor- do not allow any genu valgum or recurvatum. Progress to dynamic single-leg balance activities (e.g. upper or lower extremity reaching, 4-way theraband, unstable surfaces, etc.) as lower extremity muscle control allows (Hewett 2002).
12. Hip hiking.
13. Lunges (e.g. anterior, lateral, etc.) emphasizing proper alignment and mechanics.

Phase II (6 weeks – 4 months) : *Strength and Neuromuscular Control*

- **Effusion should be ≤1cm by 6 weeks.**
- **P/AROM should be equal, bilaterally, by 10 weeks.**
- Emphasize concepts of frequency, duration and intensity of training.
- Continue to emphasize supervised balance and endurance training in the clinic.
- Encourage continuation of lower extremity strengthening at local gym or health club between formal PT sessions.

Suggested Interventions:

1. Progress endurance training (e.g. bike, Elliptical,Versa Climber, etc.)
2. Progress static and dynamic single-leg balance activities to unsteady surfaces (e.g. pillow, half foam roll, BAPS board, etc.) as lower extremity muscle control allows.
3. Begin knee extensions on isotonic machine (90-45^{O} only) if minimal effusion (i.e. ≤1cm), and no patellofemoral pain and/or patellar tendon pain.
4. Leg Press – add resistance and work into increased ranges of flexion , avoiding endranges of extension (Escamilla 2012).

12 - 16 Weeks

- Re-assess patient's independent strengthening program, ensuring proper weight progressions, training intensity, etc. Some patients may be able to decrease frequency of therapy sessions provided they are working hard on a strength and balance program.

Suggested Interventions:

1. Initial Y balance test at approximately 12 weeks.

2. Fitter and/or slide board if available.
3. Advance balance and neuromuscular control to include perturbation drills on wobble board, BOSU, half foam roll, etc. Include core and glute work to control dymanic valgus, IR moment – plank progressions, single leg squat or lunge resisting valgus pull from a sport cord, Pallof press/ stir the pot, low to high cable row, lateral band walks, single-leg Romanian deadlifts, etc.

Phase III (4 months- 5 months): Late Stage Strengthening, Return to Running

Criteria to Begin This Phase:

- Full ROM.
- Trace to no effusion
- No abdormal gait patterns during fast treadmill walk for 15 min (Joreitz 2016).
- 30 step holds without loss of balance or excessive motion outside of the sagittal plane (Joreitz 2016).
- 10 consecutive single leg squats to 45 degreees without loss of balance, lateral trunk lean, pelvic tilt, femoral IR or knee valgus (Joreitz 2016).
- 80% symmetry on unilateral leg press test (0-90 degrees) can calculate as a one rep max or max reps at body weight.
- No side to side deficits greater than 4 cm on Y balance test and 90% composite score (Joreitz 2016, Lehr 2013).

Suggested Interventions:

1. Begin straight ahead jogging – treadmill or rubberized track (may begin earlier only with MD approval). Encourage a gradual walk to jog progression (Adams 2012). Monitor for any swelling or changes in gait pattern and adjust program as indicated
2. Continue to progress strength, neuromuscular program. Increase resistance and include interventions to address deficits both above and below the knee.

Phase IV (5-7 months): Jumping, Landing, Light Agility

Criteria to Begin this Phase

- Audibly rhythmic foot stike patterns with treadmill jogging at least 6 mph (Myer 2006).
- Able to run 2 miles continuously without increased pain, swelling, warmth, or gait deviations (Joreitz 2016).
- Leg press test symmetry 85% (Joreitz 2016).

Suggested Interventions:

1 . Skipping, side shuffle , carioca, light agility ladder drills, straight plane change of direction – front to back, side to side without hard cutting; start at walking speed and encourage proper form
3. Two legged jumping drills- jump squats, jump rope , broad jumps, box jumps, vertical jumps, progressing to lateral and rotational jumps.
4. Advance to bounding drills (one leg take-off, landing on the opposite leg) to encourage a safe one leg landing both forward and lateral.
5. Advance towards straight plane sprinting- ensure there is adequate space to slow down gradually- e.g. jogging curves and sprinting straights on a track.
6. Advance strength work, stressing the need to continue unilateral training. Monitor for return of symmetrical quad tone and mass.

Phase V: (6-9 months) : Hopping and Cutting

Criteria to Begin this Phase

- Patient will show safe mechanics without compensation for a bilateral drop jump landing. Use slow motion video analysis if available. Score of 0 on iLESS testing or similar drop jump testing procedure (control of knee valgus, proper knee flexion angles, and quiet/soft landing) (Cortes 2013). Also monitor to ensure both feet contact the ground at the same time, and no lateral trunk lean away from injured side (Bell 2014).
- Able to perform light agility drills without valgus moment or feelings of instability.
- 90% symmetry on leg press test – max reps at body weight, or calculated 1 rep max.

Suggested Interventions:

1. S curve running, figure 8s, progress to 45 degree and 90 degree angle cutting starting at controlled speeds.
2. Progress to unanticipated cutting or jumping/hopping drills- ball reaction drills, auditory or visual cues.
3. Advance speed and distance with sprinting.
4. Progress into hopping (one leg takeoff, land on same leg) once good form and control are demonstrated.
5. Advance to improve distance and height during both single and multiple hopping tasks; forward, lateral, rotational; always insist on soft landing with adequate control of knee flexion angle and valgus moment. Use video analysis to provide feedback.
6. Begin working on explosive power as well as eccentric strength for controlled landings – box jumps and hops, one leg vertical jumps, box drop jumps progressing from bilateral to unilateral landing. Tailor interventions to the demands of the athlete's sport.
7. Begin functional hop testing to determine limb symmetry index using a battery of tests, based on space and equipment available at the clinic.
    - Single hop, triple hop, crossover hop (Myer 2011, Reid 2007, Noyes 1991)
    - One leg vertical hop (Gustavsson 2006, Petschnig 1998)

Phase VI: (8-9 months+) Return to Sport / Injury Prevention

Criteria to Begin this phase:

- 90% or greater symmetry in a battery of hop tests.
- Functional Agility Testing- must achieve 90% symmetry or pass raw score.
    1. Modified Agility T-test: 90% symmetry, males 10.4 sec or less , females 10.8 sec or less (Myer, Schmitt, Brent 2011).
    2. Lower extremity Functional Run: Males 18-22 sec, Females 20-24 sec (Joreitz 2016).
- Patient should demonstrate confidence and eagerness to return to play. ACL-RSI score of 62 or greater, or ACL-RSI Short Form score of 60 or greater (Webster 2018). If physical ability significantly exceeds psychological readiness, consult with MD to discuss possible referral to sports psychologist.

Suggested Interventions:

1. Continue to progress functional activities and sport specific drills as tolerated- figure 8s, full speed cutting, 10 yard pro-agility run.

2. Patient should demonstrate proficiency in performance of an injury prevention program such as the PEP Program, FIFA 11+ or Sportsmetrics to be used as a warm up prior to practice or competition. (Arundale 2018).
3. The patient will move through the following progression, prior to return to competition (Adams 2012). Communication with coaches, parents, and athletic training staff is crucial at this stage.
    - Full speed agility training without pain or apprehension.
    - Unopposed practice of sports-specific s skills without pain or apprehension.
    - One-on-one opposed practice of sports-specific skills.
    - Full practice activity with the team, including scrimmaging.
    - Limited game minutes, monitoring for signs of excessive fatigue or compensation.

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