OAH Return-to-Sport after PCL
Non-Operative Rehabilitation
Clinical Examination

- A PCL injury patient is typically less aware of the sprain/tear. They usually do not hear or feel a "pop" or "tear", as is common in ACL and MCL injuries, and they report vague symptoms of unsteadiness or discomfort, that can be difficult for the patient to specify the exact location.
- During acute phase of PCL injury, the patient may express mild to moderate swelling, stiffness, mild to moderate pain in the posterior knee, and pain with deep knee flexion such as squatting or kneeling
  - Instability may be present when the patient is performing rapid directional changes, however, this is more likely reported in patients who have sustained a PCL sprain/tear with ACL or other concomitant multi-ligamentous injuries, as well as, PCL with PLS injuries.
- During sub-acute or chronic phases of a PCL injury, the patient may have vague anterior knee pain, as well as, pain with ascending or descending stairs or with sprinting/running at full stride and deceleration.
  - Pain tends to be progressive over time and becomes localized to the patellofemoral and medial knee compartments
- **Mechanism of Injury** is typically a posteriorly directed force applied to the proximal tibia- for athletes is typically a fall to the ground on a flexed knee with the foot plantarflexed, such that the tibia strikes the ground first.
  - The exact mechanism of injury can be telling of if patient may have also sustain concomitant injures with the PCL injury
  - Hyperflexion is most likely to produce isolated PCL injuries, the soft tissue approximation of the posterior thigh and leg muscles limit posterior translation and therefore less likely to have posterior capsule involvement
  - Hyperextension injuries, the patient typically has contusions to the anterior aspects of the articular surfaces of the tibia and femoral condyles in addition to the PCL injury. Frequently an ACL rupture is often sustained in hyperextension injuries.
  - Varus and Valgus stress injuries typically occur in conjunction with rotational stresses and involve multiple ligaments (collateral and cruciate). It also often involves meniscal tears and chondral injuries at the site of tibiofemoral impact.
    - Grade II-IV Cartilage lesions- Most commonly occur at either the medial femoral condyle (50%) or patellar (33%) and the 76% of the time are found in combined PCL injuries versus Isolated PCL injuries.
- **Gait and Weight-Bearing** should be assessed (static and dynamic alignment of the knee is essential with the diagnosis of PCL deficiency/injury
  - Commonly they present with tibial external rotation, genu recurvatum, or a bent-knee gait to avoid terminal knee extension (not present on the uninvolved leg)
- **ROM** should be assessed and compared to the uninvolved lower extremity
  - Patient may have a 10° to 20° lack of knee flexion compared to the uninvolved knee
    - The lack of knee flexion may be attributed to altered biomechanics of the knee (tibia moving on the femur) creating a lack of the normal restraint to posterior tibial

displacement, whereas the tibia can shifts posteriorly earlier during knee flexion, so the endpoint is reached prior to what the knee would have with normal biomechanics.
    - Knee effusion and pain can also be contributors to the decrease in ROM

- **Special Tests:**
- **Tests for PCL Injury:**
  - These tests are based on a relationship between the medial femoral condyle and the medial tibial plateau
    - A Grade I Injury is represented by posterior translation between 1-5mm
    - A Grade II Injury is between 6-10mm, where the anterior border of the tibial plateau is lying flush with the femoral condyle
    - A Grade III Injury is greater >10mm, with the anterior border of the tibial plateau lying posterior to the femoral condyle
    - A Grade III Posterior Drawer and >10 mm of posterior tibial translation is suggestive of additional injury to the posterolateral corner (PLC)
  - The Posterior Drawer Test: It is reported to be the most sensitive (90%) and specific (99%) for identifying PCL injuries. (+LR=90, -LR=0.10)
    - It is performed with the patient supine with their hips flexed to 45° and knees flexed to 90°. The tibia is in neutral position (no rotation) with their foot flat on the examination table (to decrease the likelihood of a false-negative test for PCL injury and a false-positive for ACL, by minimizing tension through the posterior lateral corner and allowing for maximal posterior tibial translation/subluxation.) The clinician stabilizes the patient's foot and palpates for the anterior joint line between the femoral condyles and the tibial plateau. Their thumbs are placed along the anterior tibial plateau with their fingers wrapped around the tibia assessing for hamstring muscle activation. A posteriorly directed force is applied to the tibia, while assessing the medial tibial plateau position in reference to the medial femoral condyle. The clinician assess/measures the amount of posterior tibial displacement and quality of end feel.
  - The Posterior Sag Test (also called the Step-Off Sign): evaluates the integrity of the PCL against gravity. It has a sensitivity of 79% and a specificity of 100%. (+LR=79, and –LR=0.21)
    - It is performed with the patient in supine the clinician lifts both of the patients hips 45° and knees to 90° of flexion. The patient is asks to relax the muscles of the lower extremities while the clinician maintains the sagittal alignment of the legs. A side-by-side comparison of the position of the tibias is observed for a posterior sag of the tibia on the femur. In a PCL deficient knee gravity will cause the tibia to rest in a posteriorly subluxed position compared to the uninvolved knee.
  - The Godfrey Test: Also tests the PCL in reference to gravity
    - The patient is asked to actively raise their knees and hips to 90° of flexion. The clinician supports the legs in this position and asks the patient to completely relax their legs, while a side-by-side comparison is made. If the PCL is deficient gravity will cause the tibia to rest in a posterior subluxed position, causing the tibia tubercle to be less prominent on the involved leg.
  - The Quadriceps Active Test: Reported sensitivity of 54%-98% and a specificity of 97%-100%. (+LR= 18, -LR=0.47
    - The patient is in supine with the knee flexed between 80°-90°, and the foot resting on the table with neutral rotation. The clinician stabilizes the foot at the ankle and asks the patient to fire their quad by trying to extend their leg sliding their foot on the table. The

clinician prevents the foot from moving and observes for positional changes at the knee. In a PCL-deficient knee, voluntary contraction of the quadriceps will anteriorly reduce the posterior subluxed tibia. A positive test for PCL disruption is a tibial reduction greater than 2 mm.

- The Whipple Test: This test has few sensitivity and specificity values in literature.
  - The patient is prone with their knee flexed to approximately 70°. The clinician grasps the distal tibia with one hand, to support the leg, and applying a posteriorly force to the tibial tubercle with the other hand. This test allows accurate clinical evaluation while avoiding quadriceps contraction.

- **PCL injuries involving concomitant injuries:**
  - The Dial Test: This test is used to differentiate between isolated PCL injuries and combined PCL and Posterior Lateral Corner (PLC) injuries.
    - There are 3 ways to perform this test- patient is either prone or supine and is performed at both 30° and 90° of knee flexion.
    - The external rotation can be assessed by comparing the medial aspect of the foot with the shaft of the femur.
    - A difference of >10° at 90° of knee flexion compared to the contralateral lower extremity is considered indicative of a PCL injury
    - An increase in external rotation of ≥ 10° at 30° knee flexion, but not at 90° of knee flexion, is suggestive of an isolated PLC injury
    - An increase in external rotation at both 30° and 90° of knee flexion, is suggestive of a combined PCL and PLC injury.
    - **In Prone:** The knees are held together and bent to 30°, with the clinician at the end of the table holding the feet in dorsiflexion. The clinician applies an external rotational force through the patient's heels with the clinician hands alongside the talo-calcaneal contours, and compares the amount of rotation of the tibial tubercle to the contralateral lower extremity. The test is repeated with the knees bent to 90°.
    - **In Supine:** The test is performed the same as in prone with the patient in supine.
    - The second way this test can be performed in supine is with one leg hanging of the edge of the table with the knee in 30° of flexion. The clinician stands beside the table and stabilizes the thigh with one hand, while the other hand performs the external rotation through the foot. The tibial tubercle motion is observed and compared to the contralateral lower extremity. If the dial test is positive then perform the test at 90° of knee flexion. For this, the thigh should not be resting on the table, either hold the leg in one hand, or rest the foot on the table while performing the rotation in 90° of knee flexion.
  - The Slocum Test: Is performing the posterior drawer test with the tibia internally and/or externally rotation. This may suggest further ligamentous injuries (combined injuries versus isolated PCL injuries).
    - Increased posterior tibial displacement with tibia internally rotates is suggestive of a concomitant MCL or posteromedial corner (PMC) injuries.
    - Increased posterior tibial translation with the tibial external rotation may be indicative of the presence of LCL or posterolateral corner (PLC) injuries.
  - Reverse Pivot Shift Test: When positive, it is indicative of a PLS disruption.

        - The patient is supine with the knee flexed to 90° the clinician grasps the patient's distal tibia with one hand and the proximal tibia with the other hand. A valgus stress and external rotation is applied through the tibia, while passively extending the knee.
        - If positive, a shift or clunk will occur at approximately 20°-30° of knee flexion. This resulted in a posteriorly subluxed lateral tibial plateau relocating anteriorly from the action of the iliotibial band.
        - Reported sensitivity is 26% and specificity is 59%, with +LR of 0.63 and –LR of 1.25.
        - *** This test is not able to test for the presence of PCL injury**
    - Varus Stress Test: This test is performed at 0° and 30° of knee flexion.
        - An increase in varus laxity at 30° is indicative of an LCL injury
        - A slight increase in varus laxity at 0° is indicative an additional injury to the posterolateral structures, whereas a significant opening at 0° is indicative of a combined injury involving one or both of the cruciate ligaments.

Rehabilitation

Keys to Rehabilitation: (Grade I or II isolated PCL Tears):

1- During Acute Management-
   a. Focus should be on reducing knee effusion, and restoring knee ROM, and on working lower extremity kinematics rather than just specific muscle groups in isolation.
2- Strengthen the Quadriceps-
   a. A stronger quadriceps encourages anterior tibial translation, as well as, may also absorb forces across the knee joint by minimizing the articular cartilage deterioration.
3- Protect Articular Surfaces-
   a. Need to select rehabilitative exercises that minimize stress across the patello-femoral joint and medial femoral condyle to prevent premature degeneration/arthritis. Open Kinetic Chain (OKC) Knee Extension from 90°-45°, and Closed Kinetic Chain (CKC) Knee Extension from 45°- full extension (0°).
   b. The presence of any pain, especially joint pain, or increased effusion during rehabilitation exercises indicates a need to reduce the exercises volume, intensity, difficulty, or resistance amount.
4- Monitor Medial Tibiofemoral Joint Pressures-
   a. A decreased load on the menisci results in an increased force transmitted through the tibiofemoral joint, secondary to the posterior laxity causing the medial menisci to function abnormally, and is believed to be the cause of many of the symptoms of disability with PCL injury.
   b. The clinician must monitor symptoms along the medial tibiofemoral joint line, because pain there is an early sign of degeneration of the knee joint.
   c. The patellofemoral joint may also present with symptoms. The tibia will sag as a result of the increased posterior laxity, resulting in increased patellofemoral shear forces during OKC exercises So, exercises that create high patellofemoral shear forces must be limited to prevent degeneration of this joint.
5- Train the Gastrocnemius-
   a. In research, during all tested knee flexion angles (with gastrocnemius tensioning), the tibia was translated anteriorly.

6- Preservation of Secondary Restraints-
   a. Research suggests that gravity and OKC Hamstring exercises can have a negative effect on PCL-deficient knees, by creating a posterior tibial translation. Resisted OKC hamstring/knee flexion exercises should be avoided, strengthen hamstrings in a CKC environment.
7- Enhance Muscle Response Time-
   a. Not much research has been devoted to this topic in PCL-deficient knee, like the ACL. However, it is advantageous for PCL-deficient knees to have strong quadriceps, so it is also important that the muscle response time be enhanced so muscle timing of the firing is appropriate. This is accomplished through challenging agility, balance and coordination.
8- Eccentric Strengthening Exercises-
   a. This type of training should be included in treatment for the quadriceps and hamstring muscles, because research has shown that the injured leg of patient tends to be weaker eccentrically for both quadriceps and hamstrings.
9- Closed-Kinetic-Chain Exercises-
   a. Should also be performed because they allow for increased neuromuscular control/re-education, for balance, coordination, and proprioception.
   b. CKC exercises help create co-activation of the antagonist muscles that can decrease tibiofemoral shear forces during active knee flexion and extension
10- Bracing and Orthotics-
   a. For a symptomatic patient, the use of a PCL Brace to mechanically minimize posterior tibia translation may be advantageous. For patients with medial compartment arthritis or a varus thrust, a lateral heel wedge may be beneficial to relieve symptoms. Research has shown lateral heel wedges to decrease adduction moment at heel strike and reduce pain in patients with mild to moderate medial compartment arthritis.

Initial Phase (Weeks 1-2)

Goals of this Phase:

1- Reduce/eliminate all swelling/edema from injured knee
2- Restore P+ AROM of the injured knee to ≥ 0°-115°
3- Restore normalized gait pattern

Treatment:

- Bracing: Some patients braced in a full extension brace for a period of 2-4 weeks depending on MD recommendations and severity of PCL injury and concomitant injuries
- Modalities:
  - Cryotherapy to control/eliminate swelling
  - ESTIM/NMES to enhance quadriceps firing
- Exercises:
  - **ROM:** is initially (week 1) through pain-free range of 0°-70°, and gradually increased per patients tolerance. Full ROM by weeks 2-4, depending on patient and severity of the injury.
  - **PROM:** With the tibia supported to minimize posterior glide of the tibia
  - **Quadriceps Exercises:** OKC extension 90°- 45° (can be with external resistance), CKC exercises 45° to full extension (Mini Squats, Terminal Knee Extension with the resistance applied to the distal knee/proximal tibia)
    - Multi-Angle isometric quadriceps strengthening (60°, 40°, 20°) can also be performed
  - **Gastrocnemius Exercises:** Weight-bearing Heel Raises [Double-leg (DL) progressing to Single-leg (SL)]

- Stationary Bicycle
- Lateral Step Ups
- **Hip and Core exercises:** for any dysfunctions found on evaluation, that does not effect restrictions for the knee.
- **Good exercises for preservation of secondary restraints:** Bilateral LE Deadlifts, Good Morning Exercise, and Bilateral and Unilateral Bridging
    - **All exercises chosen should be able to be performed without reproduction of symptoms**

Criteria for progression to next phase:

1- 0°- ≥ 115°, and should be pain-free
2- Normal gait pattern
3- Absence of swelling/edema of injured knee
4- Good quadriceps contraction.
5- No pain with any exercises from Initial Phase

Intermediate Phase (~ Weeks 3-6)

Goals of this Phase:

1- To restore full A+PROM of the injured knee
2- To be able to discontinue used of mobilizer (per MD)
3- To restore quadriceps strength to within 80%-90% of the uninjured leg
4- Advance to an aggressive strengthening and proprioceptive exercises- **When Quadriceps strength is good**
5- Get a baseline FMS, Y-Balance assessment and the first 4 Hop Tests: (1-SL hop for distance test, 2-triple hop for distance test, 3- triple cross over hop test, 4- The 6-meter timed hop test), scores at ~ week 4-6

Treatment:

- Bracing: Typically discontinued by weeks 3-4, dependent upon MD recommendations for patient's progression
- Modalities:
    - Continue any/all modalities PRN
- Exercises:
    - **ROM:** A+PROM, By week 3 patient should have 0°-115°, and progress exercises that promote achievement of full knee ROM by approximately week 4-6
    - Continue all above exercises progressing weights
    - Knee Extension (90°- 0°), Hip Abduction & Adduction exercises
    - **Quadriceps Exercises:** If quadriceps firing and strength is good, than the patient can be progressed to an aggressive strengthening and proprioception programs
        - Progression exercise examples: unilateral dead lifts, resisted plantar flexion, step-ups, backward walking on the treadmill, balance, and reactive training exercises
    - Wall Squats (0°-75° initially), Vertical Squats (0°-60° initially)-> Goblet Squats-> Sumo Squats
    - Hamstring curls (zero/light resistance) (0°-45°)
    - Once quadriceps strength is 85% compared to the uninjured leg and quadriceps peak torque to Body Weight ratio to ≥80%, good neuromuscular control of the knee (no visible lag or varus/valgus movements with exercises), and demonstrate improved endurance, running drills and light agility training may be incorporated (typically ~ 4-5 weeks)
    - Begin Walk-to-Run Protocol at 4-6 weeks post-injury

Criteria for progression to next phase:

1- Full A+PROM of injured knee, comparable to uninjured knee
2- No pain or increased effusion during or after performing exercises
3- Demonstration of good knee and quadriceps strength and neuromuscular control (see above criteria)
4- No varus/valgus movement or knee pain with Single-Leg Squat Test
5- Score within gender/age/sport averages with Core Testing (see test list)

Return to Activity Phase (~ 7-12 Weeks)

Criteria for entering this Phase:

1- Full ROM
2- A score of ≥14/21 on the FMS Assessment Screen
3- No statistical asymmetries and 90% of standards of peers on the Y-Balance Assessment
4- Hop Tests (90% or higher compared to non-injured leg)
5- Limb Symmetry Index (LSI) of 90% or greater on hop tests
6- IKDC Score ≥ 85%, or the KOOS score of ≥85
7- KOS-Sports Score 90% or greater
8- No change in knee laxity (clinical exam or </=2mm on KT 2000 test)
9- Isokinetic testing: (if available)

i. Quadriceps (80% or greater) compared to non-injured leg
ii. Hamstring (100%-110%) compared to non-injured leg
iii. Hamstring-Quadriceps Ratio (70% or greater)

Goals of this phase:

1- Continue to restore maximal strength, ROM, and normalize proprioceptive/neuromuscular control of the injured knee
2- Repeat FMS and Y-Balance assessments ~ every 4 weeks after initial testing and at the end of this phase
3- Begin Interval Running protocols
4- Begin Plyometric protocol
5- Progress skill training
6- Perform Return to Sport Activity Testing (Power, Agility, Speed, Repeat Hop Tests with the addition of Hop-to-Stop tests)
7- Gradually return to sport specific training

Treatment:

- Exercises:
  - Begin and progress Interval Running Protocol
  - Continue quadriceps strengthening and any other exercises to address any deficiencies found during assessments and visual observations of movement
  - Begin Plyometric protocol at weeks 7 progressing through all 3 phases to week 12
- Continue agility, reactivity, and endurance drills/exercises:
  - Cariocas, zigzags, side-shuffling
  - Begin sudden start and stops, figure-8's, 45° and 90° cutting drills, box jumps (progressing & varying heights up to 20cm)- **(When functional testing and observation suggests clearance)**

Functional Testing: for progression to sport-specific training- can be perform over multiple days- See Attached Sheets

Strength and Power Testing:

- Single-Leg Squat test/ Single-Leg Squat test
- Vertical Jump test
- Figure-8 Hop test
- Up-Down test
- Hexagon test (DL), Modified Hexagon Hop test (SL)

Speed, Agility, and Quickness Testing:

- T-Test
- Three-Cone Drill Test
- Slalom Test
- Backward Movement Agility Test
- Zigzag Run Test

Core Testing:

- Segmental Multifidus Test
- Trunk Curl Up Test
- Double-Leg Lowering Test
- Side Bridge Test
- Prone Bridge Test
- Supine Single-Leg Bridge Test
- Extensor Endurance Test

Function and Balance Testing:

- FMS Assessment Screen
- Y-Balance Test

***Return-to-Sport Protocol- See Specific Sport Return-to-Sport Protocols**

Criteria for Return-to-Sport Specific Protocols:

- A score of ≥16/21 on the FMS Assessment Screen
- Y-Balance Test- No asymmetries and statistically equal (100%) to peers with data analysis through the software (Move to Perform®)
- Limb Symmetry Index (LSI) 0f ≥95% on hop tests
- Isokinetic testing: (if available)
  - Quadriceps (90% or greater) compared to non-injured leg
  - Hamstring (100%-110%) compared to non-injured leg
  - Hamstring-Quadriceps Ratio (80% or greater)
- IKDC score of ≥85%, or KOOS score of ≥90
- Knee Outcome Survey-Sports Activities Scale (KOS-SAS): ≥ 95%
- SL Hop tests ≥95% compared to non-injured leg
- No discomfort or swelling, and passing/statistically equal to normative values (if available) with above Functional Tests

References

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