

## The Posterior Cruciate Ligament

The Posterior Cruciate Ligament (PCL) is the strongest ligament in the knee (2 times as strong as the ACL) and provides a significant amount of knee stability. PCL deficient knees are susceptible to degeneration at the medial femoral compartment and the patello-femoral joint due to the increased translation at these joint surfaces. The PCL is approximately 38mm in length and 13mm wide. It runs from the medial femoral condyle to the posterior tibia. It is composed of two distinct bands (anterolateral and posteromedial) and is closely connected to the menisco-femoral ligament. The bands are named with respect to their anatomic location with the femoral insertion specified first followed by the tibial insertion. The anterolateral band is twice as large as the posteromedial band and 1.5 times stronger. It becomes taut with knee flexion whereas the posteromedial band tightens with knee extension.

The PCL provides 95% restraint to posterior tibial translation and acts as a secondary restraint to tibial external rotation, varus, and hyperextension. With PCL rupture, there is an increased posterior translation when a posterior load is applied to the tibia and this translation increases as knee flexes with maximum translation from 70-90°, where the ACL is on full slack. Isolated PCL tears are uncommon due to the strength of the PCL.

There is much debate as to whether one should reconstruct a ruptured PCL or opt for conservative treatment. Many studies have shown that isolated PCL tears do well with conservative treatment. Conservative treatment of the PCL should focus on quadriceps rehab and protective weight bearing. Hamstring activity should be restricted due to the posterior pull the hamstrings elicit on the tibia. Quad activity helps counteract this posterior pull and should be addressed aggressively. Open kinetic chain activities are advised from 60-0° and closed chain activities from 0-60°. The therapist must watch for patellar pain due to the increased tibial drop back present with a ruptured PCL. The therapist must also be aware that the lateral structures of the knee act as secondary stabilizers to posterior translation and need to be guarded initially.

### Overview

The Posterior Cruciate Ligament or PCL, and the Anterior Cruciate Ligament (ACL) , limit the motion of the tibia backward and forward, respectively.

The lateral collateral ligament (on the outside of the knee) and the medial collateral ligament (on the inside of the knee) limit side-to-side knee motion.

Fifty percent of PCL injuries occur in conjunction with other knee ligament injuries, while the other 50 percent occur alone and are referred to as isolated PCL injuries. PCL tears usually result from high force impacts, generally vehicular accidents or contact sports such as football, soccer, or hockey. PCL injuries also can occur in non-contact sports, such as gymnastics or skiing, but are much less common.

A PCL injury usually occurs during a direct hit below the knee while the leg is bent. In other cases, you may land directly on a bent knee, driving the tibia up and behind the knee and tearing the PCL. Extreme hyperextension of the leg (straightening beyond the normal limit) is a third type of trauma that may result in tears to the PCL and other knee ligaments.

If untreated, a torn PCL can change knee mechanics, resulting in abnormal motion and subsequent pain and instability. Over years, this wear and tear can lead to progressive degenerative arthritis.

#### Diagnosis

Symptoms of PCL injuries include:

- marked, immediate swelling (within three hours of the injury)
- difficulty in walking after the injury
- pain when moving the knee
- an occasional feeling of instability or the knee "giving way"

Unlike the "pop" and severe pain that may occur with a torn ACL, an isolated PCL injury may manifest itself simply as swelling in the knee that subsides over a few days or weeks. In many cases, patients may overlook the initial injury and fail to visit a doctor or specialist for evaluation. Unlike ACL injuries, isolated PCL injuries may not initially limit knee function, allowing you to return to normal activities.

Diagnosis of a PCL injury begins with an extensive history to learn how the injury occurred. The doctor must determine what position the leg was in at the time of injury and whether the injury involved contact or a noncontact mechanism (for example, twisting). In an acute, isolated PCL injury, there is usually a history of mild pain and swelling. If the PCL and other knee ligaments are torn, the knee is severely swollen and the person is completely disabled.

Once a thorough history is obtained, the examiner performs a physical exam of the knee to assess the stability of the ligaments. Using specific tests, the physician can diagnose PCL injuries by applying forces to the knee and feeling for abnormal motion.

The examiner also must assess other knee ligaments to rule out combined ligament injuries. In severe, multiple ligament injuries, nerves and blood vessels also may be damaged. These injuries must be evaluated immediately by a doctor.

It is difficult at times to completely assess all the damage that may have occurred in conjunction with a PCL injury. In this case, obtaining additional studies such as magnetic resonance imaging (MRI) exams can be very helpful. Magnetic resonance can show the ligaments, cartilage, and bone to give an accurate picture of the extent of the injury.

## Posterior Cruciate Ligament Reconstruction

This protocol is a guideline for your **rehabilitation after posterior cruciate ligament reconstruction**. You may vary in your ability to do these exercises and to progress from one phase to the other.

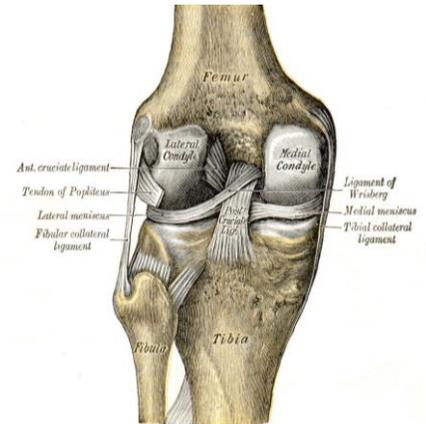
Please call Dr. Gill's office if you are having a problem with your knee or if you need clarification of these instructions.

### **PHASE I: 0 – 2 weeks** after surgery

You will go home with a **knee brace, crutches, cryocuff cold therapy unit and a CPM machine**.

### **GOALS:**

1. Protect the reconstruction – avoid falling
2. Ensure wound healing
3. Attain and maintain full knee extension
4. Gain knee flexion (knee bending) to 90 degrees
5. Decrease knee and leg swelling
6. Promote quadriceps muscle strength
7. Avoid blood pooling in the leg veins



### **ACTIVITIES:**



#### **1. BRACE/CRUTCHES**

For the first two weeks after surgery, your knee brace will be locked in extension (straight). Use the brace when walking.

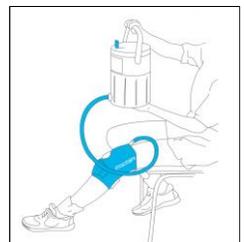
You will be asked to use crutches to walk after surgery. You will be instructed in partial weight bearing with the crutches for at least the first 6 weeks after surgery. Your doctor will give special instructions in some cases.

Remove the brace for exercises



#### **2. CRYOCUFF (COLD APPLICATION)**

If you are experiencing pain, swelling, or discomfort, we suggest icing for 15-20 minutes with at least a 60-minute break in between. Use your cryocuff or place ice in a zip lock bag and/or in a towel and apply to the injured area. Never place ice directly on the skin.



### **3. WOUND CARE**

Remove your bandage on the second morning after surgery but leave the small pieces of white tape (steri strips) across the incision. You can wrap an elastic bandage (ace) around the knee at other times to control swelling. You may now shower and get your incision wet, but **do not** soak the incision in a bathtub or Jacuzzi until the stitches have been removed.

### **4. ASPIRIN / ELASTIC STOCKINGS**

Take an aspirin each morning; wear elastic stocking (TED) below the knee for 2 weeks, and do at least 10 ankle pump exercises each hour to help prevent phlebitis (blood clots in the veins).

### **5. FREE/MACHINE WEIGHTS**

#### **Upper Body/Trunk Only**

We suggest that you do not use any lower extremity free or machine weights. If you are doing free or machine weights for the upper body and trunk, we suggest a very light resistance of 3 sets of 15-20 repetitions. Do not place yourself in a compromising position with your recently operated knee. Do not do exercises while standing. Use a bench or chair to support your body weight.

### **EXERCISE PROGRAM**

Perform exercises without brace. See “Knee Exercises” handout for illustrations. You can view a video clip of most of the listed exercises by going to the Boston Sports Medicine and Rehabilitation Institute website: <http://www.bostonsportsmedicine.com>

Days per Week: 7 Times per Day: 3-4

Quadriceps setting	1-2 sets of 15-20 reps
Heel prop	5 minutes
Sitting Heel Slides	1 set of minutes
Straight leg raises	1-2 sets of 15-20 reps
Patellar mobilization	1 set for 1 to 3 minutes
Hip abduction	3 sets of 10 reps
Ankle pumps	1 set of 2 to 3 minutes

### **START PHYSICAL THERAPY**

- You can start formal physical therapy about 3 to 5 days after the operation.
- We ask that your PT follow our written protocol.
- If your PT has questions, please ask them to call us to discuss them.



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**OFFICE VISIT**

Please return to Dr. Gill's office approximately **two weeks** after your surgery. At this time, your sutures will be removed and your progress will be checked. You will begin CPM at this time.

## Posterior Cruciate Ligament Reconstruction

### PHASE 2: 2 – 6 weeks after surgery

#### Goals

1. Protect the reconstruction, avoid falling
2. Ensure wound healing
3. Maintain full knee extension (straighten knee fully)
4. Begin quadriceps muscle strengthening
5. Attain knee flexion of 90 degrees or more
6. Decrease knee and leg swelling
7. Protected gait with crutches and partial weight bearing

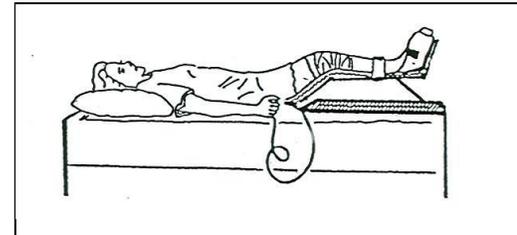
#### ACTIVITIES

##### 1. Continuous Passive Motion (CPM)

Use the CPM machine at home as much as possible for **3<sup>rd</sup> and 4<sup>th</sup> weeks after surgery**. **You should use the machine at least 10 hours per day**. You may move the machine to a sofa, the floor or onto a bed as you change positions and locations. You should use the machine at night while sleeping; slow down the machine at night to facilitate sleeping. **Extension** (knee straight) on the machine should be set at **minus five degrees** at all times to help your knee extend.

#### It is very important that you straighten the knee

**completely!** The machine should be programmed to include an extension pause of 5 seconds (in other words, when the knee is straightened out, it pauses in the straight position to allow you to stretch it out straight). This flexion setting will start at around 30 – 40 degrees and should be gradually increased to 90 degrees as you can tolerate more bending of your knee.



##### 2. Cryocuff

Use the cryocuff or ice bags to decrease swelling for 20 minutes three times a day after each exercise session.

##### 3. Brace / Crutches

Always wear the post-operative brace when walking (the brace should be set to allow full extension and 90 degrees of flexion). Always use your crutches and bear only **partial weight** on the operated leg. Follow these instructions until you return for your follow-up with your doctor at six weeks after surgery

#### **4. Swelling**

Continue using the elastic stockings (TED) for the lower leg and wrapping the knee with an elastic bandage (ACE) to control swelling.

#### **5. Exercise Program**

##### **Stationary Bicycle**

Utilize a stationary bicycle to move the knee joint and increase knee flexion. If you cannot pedal all the way around, then keep the foot of your operated leg on the pedal, and pedal back and forth until your knee will bend far enough to allow a full cycle. Use the non-operated ('good') leg to move the pedals while your operated (PCL) leg just travels around as a 'passenger'. Most people are able to achieve a full cycle revolution backwards first, followed by forward. You may ride the cycle with no resistance for up to 10-15 minutes, 1 to 2 times a day. Set the seat height so that when you are sitting on the bicycle seat, your knee is fully extended with the heel resting on the pedal in the fully bottom position. You should then actually ride the bicycle with your forefoot resting on the pedal.

##### **Range of Motion and Strengthening Exercises** (brace off)

Continue the exercises from phase 1.

##### **RANGE OF MOTION AND STRENGTHENING EXERCISES** (brace off)

Days per Week: 5-7                      Times per Day: 1-2

Quadriceps setting	1-2 sets of 15-20 reps
Heel prop	5 minutes
Heel slides with towel assist	1 set of 5 to 15 minutes
Straight leg raises	1-2 sets of 15-20 reps
Standing Toe Raises	3 sets of 10 reps
Standing toe-raises	3 sets of 10 reps
Hip abduction	3 sets of 10 reps
Short Arc Lift	3 sets of 15 reps
Prone Hip Extension	3 sets of 15 reps

##### **OFFICE VISIT**

Please arrange to see your Dr. Gill in four weeks (6 weeks after surgery).

## Posterior Cruciate Ligament Reconstruction

### PHASE 3: 6-12 weeks after surgery

#### Goals

1. Protect the reconstruction, avoid falling
2. Ensure wound healing
3. Maintain full knee extension (straighten knee fully)
4. Begin quadriceps muscle strengthening
5. Attain knee flexion of 90 degrees or more
6. Decrease knee and leg swelling
7. Return to normal walking without crutches

#### ACTIVITIES

##### 1. Cryocuff

Use the cryocuff or ice bags as needed to decrease swelling for 20 minutes.

##### 2. Brace / Crutches

You can discontinue use of the brace and crutches according to your Dr. Gill's instructions

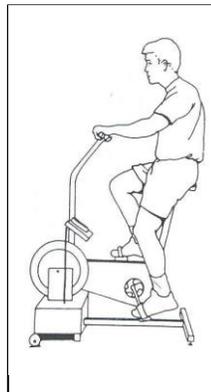
##### 3. Exercise Program

#### Stationary Bicycle

Utilize a stationary bicycle to move the knee joint and increase knee flexion. If you cannot pedal all the way around, then keep the foot of your operated leg on the pedal, and pedal back and forth until your knee will bend far enough to allow a full cycle. Most people are able to achieve a full cycle revolution backwards first, followed by forward. You can now ride the bike normally, using both legs actively. You may ride the cycle with mild resistance for up to 10-15 minutes, 1 to 2 times a day. Set the seat height so that when you are sitting on the bicycle seat, your knee is fully extended with the heel resting on the pedal in the fully bottom position. You should then actually ride the bicycle with your forefoot resting on the pedal.

#### Range of Motion and Strengthening Exercises (brace off)

The following exercise program should be followed as directed by Dr. Gill or the physical therapist. For the straight leg raise, hip abduction and prone hip extension, if the exercise can be performed easily after the first week, then an ankle weight may be used to increase the resistance of the exercise and build strength. Start with 1 pound and add 1 pound per week until you reach 5 pounds. Do the exercises daily for the first week, and then decrease to every other day when using ankle weights.



3 sets of 10 repetitions is recommended for all exercises. You may ride the stationary bicycle daily for 20 to 30 minutes.

## **EXERCISE PROGRAM**

### **Range of Motion and Strengthening Exercises**

Days per week: 3

Times per day: 1

Quadriceps setting	1-2 sets of 15-20 reps
Heel prop	5 minutes
Short arc lift	3 sets of 10 reps
Heel slides with towel assist	1 set of 5 to 15 minutes
Straight leg raises	3 sets of 10 reps
Standing hamstring curl	3 sets of 10 reps
Standing toe-raises	3 sets of 10 reps
Hip abduction	3 sets of 10 reps
Partial squat to chair	3 sets of 10 reps
Wall slides	3 sets of 10 reps
Prone Hip extension	

### **OFFICE VISIT**

Please arrange to see Dr. Gill 3-4 months after surgery.

## Posterior Cruciate Ligament Rehabilitation Protocol

### PHASE 4: 12 to 18 weeks after surgery

#### **Goals:**

1. Protect the reconstruction; avoid falling.
2. Maintain full knee extension.
3. Attain full knee flexion.
4. Walk with a normal heel-toe gait with no limp.
5. Muscle strength and conditioning improvements.

#### **1. Brace / Crutches**

The brace and crutches are usually discontinued after you see the doctor at your 6-week post-operative office visit. Concentrate on walking with a heel-toe gait without a limp.

#### **2. Cryocuff**

Continue to use the cryocuff, as needed, for 20 minutes after each workout.

#### **3. Knee Support**

Buy an elastic knee sleeve (made of neoprene rubber) at a sporting goods store. It should have an opening for the kneecap and velcro straps but does not need hinges on the sides. Use this support if you are on your feet for a prolonged period of time.

#### **4. Stationary Bicycle**

Utilize a stationary bicycle to both strengthen the thigh muscles and increase knee flexion. If you cannot yet pedal all the way around, then keep the foot of your operated leg on the pedal, and pedal back and forth until your knee will bend far enough to allow a full cycle. You may ride the cycle with mild resistance for up to 20 minutes a day. Set the seat height so that when you are sitting on the bicycle seat, your knee is fully extended with the heel resting on the pedal in the fully bottom position. You should then actually ride the bicycle with your forefoot resting on the pedal.

#### **5. Swimming**

You may begin swimming at this time, if available, using only the flutter kick and doing the freestyle and backstroke. Do not swim breast-stroke, butterfly or side-stroke yet. Swimming with a kick-board is safe as long as the flutter-kick is used. You can swim up to 15 to 20 minutes, 3 to 4 times per week.

#### **6. Exercises**

Quadriceps setting exercises should continue for 20 repetitions, 3 times per day. Continue the exercises from Phase 2 as a warm-up to the Phase 3 exercises. You should add the following exercises, every other day, as instructed by the physical therapist:

## **EXERCISE PROGRAM**

### **Range of Motion and Strengthening Exercises**

Days per week: 3

Times per day: 1

Quadriceps setting	1-2 sets of 15-20 reps
Heel prop	5 minutes
Heel slides with towel assist	1 set of 5 to 15 minutes
Straight leg raises	3 sets of 10 reps
Standing hamstring curl <b>limit to 45°</b>	3 sets of 10 reps
Standing toe-raises- single leg	3 sets of 10 reps
Hip abduction	3 sets of 10 reps
Prone hip extension	3 sets of 10 reps
Squat to chair	3 sets 15 reps
Wall slides	3 sets of 15 reps
Single leg strengthening progression	see timeline

### **Stretching Exercises**

Days per week: 5-7

Times per day: 1-2

Hamstring stretch	3-5 reps holding 15 to 30 seconds
Quadriceps stretch	3-5 reps holding 15 to 30 seconds
Calf Stretch	3-5 reps holding 15 to 30 seconds

### **Optional Additional Weight Training**

Days per week: 2-3

Times per day: 1

3 sets of 20 repetitions

The following exercises may be added to your exercise program about 6 weeks after surgery:

Seated Leg Press	Roman Chair
Hamstring Curl	Calf Raise Machine
HIP Abductor/Adductor Machine	Hip Flexor Machine

## **SINGLE LEG STRENGTHENING PROGRESSION**

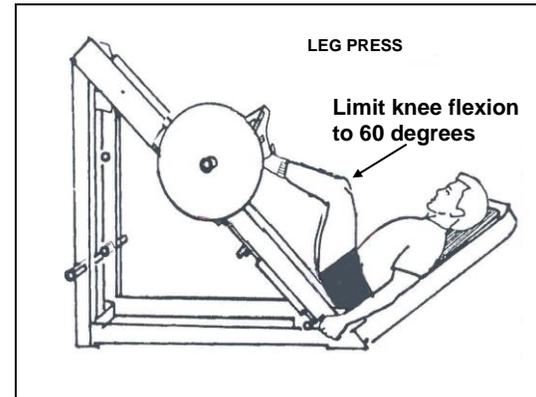
At this time, it is important to begin the development of single-leg strength. Begin to follow the “Progression for Single Leg Strengthening ” included in this packet if you are able to do the exercises without pain. The instructions estimate a time period of 10 to 12 weeks for you to progress through the whole program. This time line will vary for different people and knees, depending upon the presence of other knee problems. Again, limit flexion of the knee to 60 degrees or less during these exercises.

## OPTIONAL ADDITIONAL EXERCISES

The following exercises may be added to your exercise program at 8 weeks after surgery:

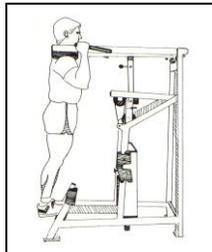
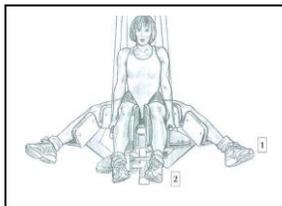
### LEG PRESS

When using a leg press machine, limit the flexion of the knee to **60 degrees** or less to avoid over stressing the PCL graft. As the starting weight for these exercises, use an amount of weight that feels easy enough to perform 20 repetitions. Use this weight for the first week before raising the weight. The weight may be increased by about 5 pounds every 7 to 10 days thereafter, as long as you can perform 20 repetitions per set for 3 sets.



### Weight Training

Leg Press  
Hip Abductor/Adductor machine  
Roman Chair  
Calf Raise Machine



### Precautions When Exercising

When using a leg press machine, squatting or doing wall slides, limit the flexion of the knee to **60 degrees** or less to avoid over stressing the PCL graft.

- When performing the standing hamstring curl, limit the bend in your knee to 45 degrees.
- Avoid pain at the surgical incision site
- Avoid pain and/or crepitus at the patella
- Build up resistance and repetitions gradually
- Perform exercises slowly avoiding quick direction change and impact loading
- Exercise frequency should be 2 to 3 times a week for strength building
- Be consistent and regular with the exercise schedule

### **Principles of Strength Training**

- Warm-up prior to exercising by stationary cycling or other means
- You are “warmed –up” when you have started sweating
- Gently stretch all muscle groups next
- Do exercises involving multiple muscle groups first and individual muscle groups last
- Do aerobic workouts after strength workouts
- Cool-down by stretching after finishing exercise

**DO NOT** do any of the following exercises:

1. Knee extension using a weight lifting machine
2. Resisted Hamstring curls or hamstring weight machine
3. Lunges
4. Stairmaster
5. Step exercises with impact
6. Running
7. Jumping
8. Pivoting or cutting

### **OFFICE VISIT**

Please make an appointment to see Dr.Gill at six months after surgery.

## Posterior Cruciate Ligament Rehabilitation Protocol

### Phase 5: from the 18<sup>th</sup> week onward

#### Goals:

1. Regain full muscle strength.
2. Work on cardiovascular conditioning.
3. Do sports-specific training.

### ACTIVITIES

#### Muscle-Strengthening Exercises

You should continue muscle-strengthening exercises from Phases 2 and 3 three times a week. You can now decrease the number of repetitions per set from 15 to 10. This will allow you to work with heavier weights. Remember to do all exercises slowly with good form. Weights can be increased when you can do a particular weight easily for 3 sets of ten repetitions for 3 consecutive workouts.

#### Cardiovascular Conditioning

Use Nordic track, stationary bicycle, rowing machine or swimming workouts to build cardiovascular fitness. Three to five times per week for 20 to 30 minutes is sufficient for improvement in conditioning. Excessively long duration cardiovascular exercise can retard or delay muscular strength development. Strength improvement and gains in muscle size are your primary goals at this time.

#### Sports-Specific Training

To reach your ultimate goal of returning to sports participation, you must follow an orderly sequence of drills which are designed to re-train coordination that is necessary to provide the proper control of your knee. The following time-table gives an approximate sequence for returning to activities:

<u>Activity</u>	<u>Months post-</u>
<u>surgery</u>	
Golf	4 to 5
Running slowly	5
Tennis	6
Sprinting	6
Running quickly with slow starts and slow stops	6
Running with sprinting with fast starts and stops	7 to 8
Backward running	7 to 8
Zigzag running	7 to 8
Figure-of-eight running	7 to 8
Circle running	7 to 8
Carioca running	7 to 8

Hopping and jump training	8 to 9
Quickly pivoting and cutting	8 to 9
Full return to sports	9

### **Progressive Resistance Exercise (PRE) Principle**

- To build muscle strength and size, the amount of resistance used must be gradually increased.
- The exercises should be specific to the target muscles
- The amount of resistance should be measurable and gradually increased over a longer period of time
- To avoid excess overload and injury, the weight or resistance must be gradually increased in increments of 5 to 10 %
- Resistance can be increased gradually every 10 to 14 days when following a regular and consistent program
- Adequate rest and muscle recovery between workout is necessary to maximize the benefit of the exercise
- If the PRE principle is followed too strictly, the weights potentially will go higher and higher.
- At a certain point, the joints and muscles will become overloaded and injury will occur.
- This eventuality can be avoided by refraining from using excessive weight during strength training.

### **Basic Knee Strengthening Program (Weeks 18 to 24 after surgery)**

- Frequency: 2 to 3 Times per week
- Sets: 3
- Repetitions per set: 10-15
- Emphasis is to build muscle strength using BOTH legs
- Progress according to the PRE principle

### Basic Program Exercises-

- Leg Press
- Standing Hamstring Curl (limit knee flexion to 45 degrees) add 1 lb. a week to reach 5 lb.
- Wall Slides (hold dumbbells for resistance)
- Roman Chair (strengthens hamstrings)
- Chair Squat (hold dumbbells for resistance)
- Calf Raises
- Hip Abductor/Adductor machine
- Step Up/Down (see attachment for progression)

If you do not have access to gym equipment, the following exercises can be substituted using ankle weights (see illustrations and instructions attached):

- Straight leg raise
- Short-arc lift
- Side lying abduction
- Standing hamstring curl
- Toe raises

In General, the Basic Knee Strengthening Program is good for most people who are active recreationally, but who do not participate in running and jumping sports. For people who will participate in running and jumping sports, the following Advanced Knee Strengthening Program can be used to develop a higher level of knee strength.

### **Advanced Knee Strengthening Program (Week 24 onward)**

- Frequency: 2 to 3 Times per week
- Sets: 3
- Repetitions per set: 10
- Emphasis is to continue to build muscle strength using both legs and progress to Advanced Exercises using the Single leg.
- Advanced Single leg exercises are integrated with the exercises from the Basic Knee Strengthening Program (see attachment for progression of single leg drills).

The following single leg drills are integrated into the workout on a rotating basis:

- Step Up/Down
- Single Leg Wall Slide
- Single Leg Squat

So that the Advanced Knee Strengthening Program would be as follows:

- Leg Press
- Hamstring Curl Machine (limit knee flexion to 45 degrees) Do not increase weight more than ½ plate per week
- Wall Slides
- Roman Chair
- Chair Squat
- Calf Raises
- Step up/down
- Alternate workouts with single leg wall slide and single leg squat
- When starting the new single leg drills, start with 3 sets of 5, and add one repetition per set, per workout until you can do 3 sets of 10.
- When 3 sets of 10 are easy and pain free, then you can hold dumbbells to increase resistance and strength.



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**DO NOT** do any of the following exercises:

1. Knee extension weight lifting machine
2. Running
3. Jumping or plyometrics
4. Pivoting or cutting
5. Lunges
6. Stairmaster
7. Step exercises with impact