Personalized Blood Flow Restriction Rehabilitation

Anterior Cruciate Reconstruction
with Meniscal Repair
PHASE 1 (PROTECTED PHASE)

Typically, after an anterior cruciate reconstruction surgery (ACL) with meniscal repair there is a protected range of motion and weight bearing period that can last up to 6 weeks. However, the large hematoma produced during the ACL surgery is considered beneficial to the healing of the meniscal repair and some surgeons are more aggressive during this time frame. Check each individual surgeon’s preference. Location of the repair, age of the patient and any other concomitant conditions (bone bruising, chondral lesions, allograft vs autograft ACL, revision) must be assessed and considered when developing a proper post-operative protocol.

The primary goals during the protected phase are pain control, reducing effusion within the joint, restoring ROM, increasing muscular recruitment to avoid Arthrogenic Muscle Inhibition (AMI) and maintaining muscular and aerobic endurance. Unfortunately, there is usually significant muscle atrophy, reduced aerobic capacity, and muscle inhibition during the protective phase, especially in the quadriceps muscle. In non-weight bearing studies the vastus muscles of the thigh and soleus typically are the first to atrophy so these should be the focus during the protective phase. The hamstrings typically have significantly less atrophy and strength loss, possibly because of its bi-articular anatomy. Additionally, active knee flexion contractions can irritate the repair by traction on the joint line. Because of this most active hamstring activity is not started until 4 to 6 weeks post-operatively. During the protective phase the total time under BFR will be approximately 20-25 minutes. This mimics the total time used in the NWB BFR studies that followed the cell-swelling hypothesis to mitigate atrophy.

You can start BFR the first week post-operatively, usually after day 3, but this is facility and surgeon specific. This protocol should be followed 2-3 days a week. Other exercises within your facility protocol should be done along with the BFR exercises. If the patient has a large hematoma, pain (that is atypical) or any other contraindications to BFR do not proceed without consulting the referring Physician.

*Note: This is a sample protocol and is only a template. You should consult with your referring Physician for your facilities specific post-operative protocol.
Personalized Blood Flow Restriction Rehabilitation goals:

» Improve muscle activation by stimulating slow (aerobic) and fast (anaerobic) twitch fibers.
» Mitigate atrophy.
» Maintain endurance.

Delfi PTS for BFR Application and Parameters:

» Cuff location at the most proximal portion of the involved limb.
» Matching limb protection sleeve under the cuff.
» Limb Occlusion Pressure (LOP) at 80%, start lower (70% and reduce as needed) if the patient cannot tolerate the pressure. LOP should be measured at the beginning of the exercise session for each individual patient. You DO NOT need to re-check LOP for each additional exercise on the same limb on the same patient during the same session.
» Target muscle groups (quadriceps/gluteals/gastrocnemius/hamstrings).

With all Traditional Strengthening Exercises

» Cuff on the involved thigh, as proximal as possible.
» Perform 4 sets of 30/15/15/15 reps.
» 30 second rest period between sets, while keeping the cuff inflated.
» Deflate the cuff immediately after the exercise is completed and allow 1-minute rest for reperfusion.

*Note: Make sure your patient gets 25 grams of protein (for example Whey shake) to take advantage of the increased protein synthesis response. This should be done right after BFR training and every 4 hours (except during the overnight fast).
Post-Op Days 1 – 14
» POD 1: Debulk dressing, TED Hose in place
» POD 2: Change dressing, keep wound covered, continue TED Hose
» POD 7-10: Sutures out, D/C TED Hose when effusion resolved
  • Brace x 6 weeks – Locked in extension for ambulation
  • Crutches – Partial weight bearing (PWB) in brace
  • Patellar mobilization (teach patient)
  • ROM 0-90 degrees (passive extension, heel slides with towel assist)
  • No active Hamstring exercises

BFR Exercises
1. **NMES at 10-20% MVC:** (low level, just enough to induce an involuntary response). 10 minutes total stimulation time. 10-second contraction with a 20 second rest. Pad placement distal to the tourniquet cuff on the vastus laterals and vastus medialis oblique. Tourniquet inflated during the entire stimulation session. Deflate immediately after the stimulation session; allow 1-minute reperfusion before moving onto the next exercise. Start with leg in full extension and progress to isometric holds with leg in 60 to 90 degrees flexion (using uninvolved limb to hold the leg or in a machine such as a Biodex locked at the desired flexion angle).

2. **Side-lying hip abduction:** (if difficult start with open clam). Start without weight and slowly add cuff weights as patient progresses. If the patient is able to complete total volume increase the load.

3. **Bent knee ankle plantar flexion:** Start with light theraband and slowly increase resistance as patient progresses. If the patient is able to complete total volume increase the load.

4. **Straight leg raises (SLR):** NO LAG! Start without weight and slowly add cuff weights as patient progresses. If the patient is able to complete total volume increase the load.

Cryotherapy with knee in full extension after exercise.

**Rehab Goals**
» Full passive extension.
» Flexion to 90 degrees.
» Good quad control.

**BFR Goals**
» Muscle swelling post-treatment to activate protein synthesis.
» Mild metabolite accumulation to induce systemic response.
» Improved muscle activation.
Post-Op Weeks 2 – 4

- Brace x 6 weeks – May open to 0-90 degrees: surgeon preference
- Crutches – PWB in brace
- Continue appropriate previous exercises
- Scar massage when incision healed
- ROM 0-90 degrees only -may alter based on surgeon preference
- No active hamstring exercises

**BFR Exercises**

D/C electrical stimulation if the patient has good quad control.

1. **Straight leg raises (SLR):** NO LAG! Start without weight and slowly add cuff weights as patient progresses. If the patient is able to complete total volume increase the load.
2. **Side-lying hip abduction:** Start without weight and slowly add cuff weights as patient progresses. If the patient is able to complete total volume increase the load. Bent knee ankle plantar flexion. Start with light thera-band and slowly increase as patient progresses. If the patient is able to complete total volume increase the load.
3. **Prone hip extension:** Start without weight and slowly add cuff weights as patient progresses. If the patient is able to complete total volume increase the load.
4. **Bent knee ankle plantar flexion:** Start with light thera-band and slowly increase as patient progresses. If the patient is able to complete total volume increase the load. Deflate the cuff immediately after the session and allow 1-minute reperfusion.
5. **LAQ 90-30 degrees:** NO ANT KNEE PAIN. No weight until week 4.

*Note: Some protocols allow patients to begin low level cycling in the protected period. If so, begin with BFR cycling protocol. See weeks 6-8 for guidance.*

Cryotherapy with knee in full extension after exercise.

**Rehab Goals**

- Pain/effusion control.
- No extensor lag/good quadriceps control.
- ROM to 90 degrees with no stiffness at end range/Full extension.

**BFR Goals**

- Continued muscle swelling to mitigate atrophy.
- Increased metabolite accumulation in muscle to augment systemic response.
Post-Op Weeks 4 – 6

- Brace x 6 weeks – May open to 0-90 degrees based on surgeon preference
- Crutches – PWB in brace
- Continue appropriate previous exercises
- Scar massage when incision healed
- ROM 0-90 degrees only -may alter based on surgeon preference
- Weight shifts

BFR Exercises

1. **Straight leg raises (SLR):** NO LAG! If the patient is able to complete total volume increase the load.
2. **Side-lying hip abduction:** If the patient is able to complete total volume increase the load. Prone hip extension. Start without weight and slowly add cuff weights as patient progresses. If the patient is able to complete total volume increase the load.
3. **Bilateral bridging (watch for joint line pain):** If the patient is able to complete total volume increase the load.
4. **Total gym/shuttle or leg press (estimated 1RM or 25% BW):** (If your facility protocol allows during this time period) 0-60 degrees. If the patient is able to complete total volume increase the load.
5. **LAQ 90-30 degrees:** NO ANT KNEE PAIN. Add light weight.

Cryo PRN

Goals

- ROM 0-90 degrees.
- No effusion.

BFR Goals

- Increased fast twitch fiber recruitment through addition of light loads.
- Increased proximal (gluteal) muscle gains.
PHASE 2

During this phase the emphasis is on restoring full ROM, improving strength and progression to full weight bearing with a normal gait. The BFR exercises during this phase begin to use more closed activities and loads close to an estimated 30% 1 RM. By doing this, you move out of mitigating atrophy to a strength and hypertrophy phase. You will also begin endurance activities such as BFR biking to improve aerobic capacity.
Post-Op Weeks 6 – 10

- D/C Brace
- Crutches – weight bearing as tolerated (WBAT), D/C when gait is WNL
- Continue appropriate previous exercises
- PROM, AAROM, AROM – Gradually increase motion through full range
- Gait training exercises. Cup walking, forward, lateral and retro walking.
- Standing SLR x 4 with light Thera-band bilaterally
- Wall squats 0-45 degrees
- Straight and bent leg calf raises. Add load as tolerated.
- Proprioceptive training (may want to perform after BFR when the leg is fatigued)

BFR Exercises

1. **Total gym/shuttle or leg press (estimated 1RM or 25% BW):** If the patient is able to complete total volume increase the load.

2. **Resisted hamstring curls or BFR bridging:** If the patient is able to complete total volume increase the load. Bilateral bridging (watch for joint line pain). If the patient is able to complete total volume increase the load.

3. **Exercise bike:** LOP 80%. Target time is 15 minutes, may need to start at 5 minutes and increase 5 minutes per session. Low resistance, level 3. If you have 2 Delfi PTS for BFR units you may perform bilateral to increase the systemic response.

*Note: If patient is still lacking significant quadriceps strength and hypertrophy [MMT and tape measure testing] continue BFR long arc quadriceps LAQ with low load in the protected range (90-30 degrees). You may also continue/add BFR strengthening to other muscle groups as needed (i.e…glutes, gastroc-soleus).

Rehab Goals

- Full pain free ROM.
- Ambulate with normal gait without assistive device.

BFR Goals

- Increased VO₂ max and muscle endurance.
- Large metabolite accumulation and muscle failure.
- Hypertrophy and strength signaling.
Post-Op Weeks 10-12

- Continue working on appropriate previous exercises
- Progress movement patterns (avoid deep squatting)
- Add additional endurance components as indicated (elliptical/swimming)

**BFR Exercises**

1. **Squatting with 30% estimated 1RM:** Avoid squatting below 90 degrees. If the patient is able to complete total volume increase the load.

2. **Split Squatting with 30% estimated 1RM:** Avoid squatting below 90 degrees. If the patient is able to complete total volume increase the load. Progress to lunges.

3. **Exercise bike or elliptical. LOP 80%:** Target time is 15 minutes, may need to start at 5 minutes and increase 5 minutes per session. Low resistance, level 3. If you have 2 Delfi PTS for BFR units you may perform bilateral to increase the systemic response.

*Note: Continue appropriate BFR training on any muscle groups still lacking. You may also add BFR to more dynamic exercises such as monster walking with thera-bands.

**Rehab Goals**

- Strength within 80% of the uninvolved limb.
- Ability to perform movement patterns such as squat, lunge-matrix, single leg without compensation.
- Begin higher level activities.

**BFR Goals**

- Continued improvement in VO$_2$ max and muscle endurance.
- Largest metabolite accumulation to induce maximal strength and hypertrophy changes.
- More complex multi-joint movements under low loads with BFR.
PHASE 3

This phase is typically 3 months and beyond. If the patient continues to lack significant strength and/or hypertrophy in the involved limb target those individual muscle groups with BFR strengthening. You may need to increase the load to improve the response.

Begin to alternate high intensity training (HIT) with BFR. Start with 1 day of HIT and 2 days BFR, then 2 days HIT 1 day BFR. If the patient tolerates HIT without any increased pain or symptoms wean off of BFR and transition to HIT training exclusively.

During this phase you can also incorporate BFR into more dynamic tasks such as multi-plane lunges with light loads.

Running programs, sport specific training and advanced movement skills should be introduced as functional and strength testing allows. BFR can be used as a performance enhancer if the athlete would like to continue strength training in season, but does not want the downtime associated with HIT from muscle damage. Periodizing HIT and BFR for performance between pre-season (HIT) and in-season/post season (BFR) training.