Evidence-based
Clinical Protocols

3) Anterior Cruciate Ligament Injury & Reconstruction

CLINICAL EDITORS
Morgan Boyle, III, MEd, ATC
Bill Galway, ATC

EDITOR
Terry McLaughlin, MS, ATC
Kenneth Rice, MS

James Andrews, MD
Mayfield Armstrong, ATCL
Jeff Beckendam, PT
Tab Blackburn, PT
Clive Brewster, PT
Marlene DeMaio, MD
Marc Galloway, MD
Terry Giove, PT
Steve Hoffman, PT
Marty Huegel, PT
Marsha Mangine, PT

Frank Noyes, MD
Russel Paine, PT
Clarence Shields Jr., MD
John Stemn, MEd, PT, ATC
Kim VanFleet, MS, ATCL
Kevin Wilk, BS, PT, REMT
Gary Wilkerson, EdD, ATCL
Michael Voight, PT
Steve Tippett, PT
# EVIDENCE-BASED CLINICAL PROTOCOL FOR ANTERIOR CRUCIATE LIGAMENT INJURY AND RECONSTRUCTION

## Table of Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>INTRODUCTION</td>
<td>3-1</td>
</tr>
<tr>
<td>REHABILITATION GOAL</td>
<td>3-2</td>
</tr>
<tr>
<td>REHABILITATION PROGRAM CONSIDERATIONS</td>
<td>3-2</td>
</tr>
<tr>
<td>DEFINITIONS</td>
<td>3-2</td>
</tr>
<tr>
<td>POST-INJURY/PRE-SURGERY PHASE:</td>
<td></td>
</tr>
<tr>
<td>GOALS (To progress to Phase I)</td>
<td>3-3</td>
</tr>
<tr>
<td>CLINICAL EVALUATION</td>
<td>3-3</td>
</tr>
<tr>
<td>CLINICAL TREATMENT OPTIONS</td>
<td>3-5</td>
</tr>
<tr>
<td>SUPERVISED PROGRAM</td>
<td>3-6</td>
</tr>
<tr>
<td>HOME PROGRAM</td>
<td>3-6</td>
</tr>
<tr>
<td>REPORTS</td>
<td>3-6</td>
</tr>
<tr>
<td>PHASE I: Reduction of Acute Symptoms</td>
<td>3-7</td>
</tr>
<tr>
<td>GOALS (To progress to Phase II)</td>
<td>3-8</td>
</tr>
<tr>
<td>CLINICAL EVALUATION</td>
<td>3-8</td>
</tr>
<tr>
<td>CLINICAL TREATMENT OPTIONS</td>
<td>3-10</td>
</tr>
<tr>
<td>SUPERVISED PROGRAM</td>
<td>3-10</td>
</tr>
<tr>
<td>HOME PROGRAM</td>
<td>3-10</td>
</tr>
<tr>
<td>REPORTS</td>
<td>3-10</td>
</tr>
<tr>
<td>PHASE II: Range of Motion and Initial Strengthening</td>
<td>3-11</td>
</tr>
<tr>
<td>GOALS (To progress to Phase III)</td>
<td>3-11</td>
</tr>
<tr>
<td>CLINICAL EVALUATION</td>
<td>3-11</td>
</tr>
<tr>
<td>CLINICAL TREATMENT OPTIONS</td>
<td>3-13</td>
</tr>
<tr>
<td>SUPERVISED PROGRAM</td>
<td>3-15</td>
</tr>
<tr>
<td>HOME PROGRAM</td>
<td>3-15</td>
</tr>
<tr>
<td>REPORTS</td>
<td>3-15</td>
</tr>
<tr>
<td>PHASE III: Initial Weight-bearing and Intermediate Strengthening</td>
<td>3-17</td>
</tr>
<tr>
<td>GOALS (To progress to Phase IV)</td>
<td>3-17</td>
</tr>
<tr>
<td>CLINICAL EVALUATION</td>
<td>3-17</td>
</tr>
<tr>
<td>CLINICAL TREATMENT OPTIONS</td>
<td>3-19</td>
</tr>
<tr>
<td>SUPERVISED PROGRAM</td>
<td>3-21</td>
</tr>
<tr>
<td>HOME PROGRAM</td>
<td>3-22</td>
</tr>
<tr>
<td>REPORTS</td>
<td>3-22</td>
</tr>
<tr>
<td>PHASE IV: Progressed Weight-bearing and Strengthening</td>
<td>3-23</td>
</tr>
<tr>
<td>GOALS (To progress to Phase V)</td>
<td>3-23</td>
</tr>
<tr>
<td>CLINICAL EVALUATION</td>
<td>3-23</td>
</tr>
<tr>
<td>CLINICAL TREATMENT OPTIONS</td>
<td>3-25</td>
</tr>
<tr>
<td>SUPERVISED PROGRAM</td>
<td>3-27</td>
</tr>
<tr>
<td>HOME PROGRAM</td>
<td>3-28</td>
</tr>
<tr>
<td>REPORTS</td>
<td>3-28</td>
</tr>
</tbody>
</table>
### PHASE V: Advanced Strengthening
- Goals (To progress to Phase VI) ................................................................. 3-29
- Clinical Evaluation.................................................................................... 3-29
- Clinical Treatment Options ..................................................................... 3-31
- Supervised Program.................................................................................. 3-32
- Home Program........................................................................................ 3-33
- Reports...................................................................................................... 3-34

### PHASE VI: Return to Activity
- Goals (Criteria to Return to Activity) ..................................................... 3-35
- Clinical Evaluation.................................................................................... 3-35
- Clinical Treatment Options ..................................................................... 3-36
- Supervised Program.................................................................................. 3-37
- Home Program........................................................................................ 3-37
- Reports...................................................................................................... 3-38

### Stability Index......................................................................................... 3-39

### References.............................................................................................. 3-41
This manual contains information that is presented by Biodex Medical Systems as part of our commitment to provide continuing service to medical professionals and to the community at large.

**IMPORTANT: READ BEFORE PROCEEDING**

Suggested courses of rehabilitation for any specific conditions are meant as references of generalized program models, and are not intended as precise prescriptions for individual treatment. The data is a compilation of information based on the work of acknowledged experts that have been published in respected journals.

We believe it is representative of current trends in scientifically derived and clinically proven principles and methods of rehabilitative medicine. Much of the published information that we review, however, is based on research and case studies involving very specific patient or test subject populations. Many research subjects, for instance, are highly trained and well-conditioned athletes prior to treatment, or are chosen because they have no known medical problems other than the condition involved in the study. It should therefore be noted that the application of any published methods should be done with extreme care, and should be based on limitations, and overall medical condition. In the presence of any doubt or question, regarding the efficacy of initiating a procedure, seek advice from appropriate sources and/or consult with the patient's physician.

**NOTE:** This protocol is intended as a guide for rehabilitation associated with knee osteoarthritis. Consider appropriate program modifications if additional tissue pathology or damage is present, associated repairs or treatments are undertaken. This protocol was not intended to rehabilitate the patient post surgically. Consult the patient's physician prior to incorporating any of the rehabilitation principles listed below.

Please send any comments or concerns to:

```
c/o Clinical Education
Biodex Medical Systems, Inc.
20 Ramsay Rd.
Shirley, NY 11967-4704
```

A special thanks goes to Terry McLaughlin, MS, ATC, Steven Jacoby, ATC and Morgan Boyle III, MEd, ATC, for their assistance in the organization of this protocol.
REHABILITATION GOAL:

The objective of rehabilitation for Anterior Cruciate Ligament (ACL) repair is to quickly and efficiently return the patient to the highest level of pre-injury activity, as reasonably possible, with minimized risk of increased signs and symptoms, related complications, or predisposing the patient to re-injury. This program can be used as a preventative measure or as an injury treatment program.

REHABILITATION PROGRAM CONSIDERATIONS

To successfully rehabilitate the patient with ACL reconstruction, the therapy team must understand:

- Basic anatomy, function, and biomechanics of the ACL and associated structures
- Mechanism of injury
- Method of repair
- Healing process following surgery

Methods to optimize:
- Patient Compliance (assess potential; establish realistic goals)
- Reduction of pain and swelling/edema
- Increases in ROM
- Increases in strength, power, and endurance
- Improvement of agility (balance; proprioception)
- Maintaining integrity of the repair (short and long term)

- Appropriate allocations of resources and time to individual patient program
- Means of evaluating individual and overall program effectiveness

DEFINITIONS:

Goals: Specific improvements which must be met in order for patient to progress to the next phase.

Clinical Evaluation: Evaluations that are only to be performed by certified and/or licensed ATC, PT or OT, in association with supervising physician’s diagnosis.

Clinical Treatment Options: Treatment options that should only be performed under the supervision of certified and/or licensed clinicians.

Supervised Program: Rehabilitation program that should be done only under the direction of appropriately qualified personnel [e.g. Certified Strength and Conditioning Specialist].

Home Program: Rehabilitation program that after proper instruction by supervising clinician can be done by patient without supervision outside the clinical setting.

Reports: Test reports are to be completed at the end of each phase to ensure progress to the next phase is indicated.
POST-INJURY / PRE-SURGERY PHASE

anterior cruciate ligament (ACL)

GOALS AND CRITERIA FOR ADVANCEMENT:

- Physically and mentally prepare patient for rehabilitation and surgery
- Quantify physiological baseline
- Regain ROM of involved knee
- Reduce swelling/edema
- Strengthen knee musculature
- Identify specific needs
- Identify potential problems

CLINICAL EVALUATION (INITIAL):

- General Patient History and Observation
- Pain: location, quality, duration, radiation, severity
- Inspection and palpation: degree, location and character of swelling/edema
- Patella: position, mobility, condition
- Range of Motion (involved): active and passive

TEST: Joint Laxity: Tibial AP displacement bilaterally

Device: joint Arthrometer, 20 lb (89 N)

TEST: Bilateral isokinetic 3 speed evaluation:
[to establish goals and monitor progress] Test uninvolved and involved on final pre-surgical visit if patient performs ADL without difficulty and decision to test is supported by clinical judgment.

Device: Biodex Multi-Joint System
Motion: knee EXT/FLEX
Report: Isokinetic Evaluation - 3 speed
Setup: full active range of motion
Percent Range: 100%
Mode: Isokinetic
Reps and Speed: 5 @ 60°; 10 @ 180°; 15 @ 300 deg/sec
Recommendations: Instruct patient to perform maximally through full ROM

TEST: Bilateral isometric 3 position evaluation: when isokinetic test of involved is not advisable.

Device: Biodex Multi-Joint System
Motion: knee EXT/FLEX
Report: Isometric Evaluation – 3 position
Setup: 30°/60°/90°
Mode: Isometric
Reps and Time: 5 @ 5 sec
CLINICAL EVALUATION (INITIAL) (cont):

TEST: Bilateral Open Kinetic Chain (OKC) Proprioception:
   Device: Biodex Multi-Joint System, knee extension/flexion
   Report: Active and passive position sense
   Setup: full active range of motion
   Percent Range: 100%
   Mode: Isokinetic
   Reps and Speed: 5 @ 60 deg/sec, 10 @ 180 deg/sec

TEST: Balance with bilateral and unilateral stance:
   Device: Biodex Balance System
   Report: Stability Index
   Stance: Bilateral and Unilateral
   Duration: 5 trials of 20 sec each stance, with a 30 sec rest between sets

NOTE: It is important to perform appropriate warm-up procedures before exercise in all clinical, supervised, and home exercise programs. 23
CLINICAL TREATMENT OPTIONS:

- Rehab process education

- Psychological preparation:
  - Compliance
  - Expectations
  - Cautions

- Reduce swelling/edema and manage pain

- P.R.I.C.E.:
  - Cryotherapy and compressive garment (neoprene or elastic) for reduction of pain and swelling/edema.

- Brace Fitting

- Ambulation Training with emphasis on "normal" gait

- Instruct on use of crutches

- Passive (PROM), Active (AROM) and Active-Assisted Range of Motion (AAROM) exercises

- Passive Range of Motion (PROM):
  - **Device**: Biodex Multi-Joint System
  - **Pattern**: Knee extension/flexion
  - **Setup**: ROM Limits set to treatment goals
  - **Percent Range**: initial settings well within current PROM
  - **Mode**: Passive Speed: 2 deg/sec initial setting
  - **Duration**: 5-15 min. as tolerated
  - **Recommendations**: Instruct patient to produce no force. Determine pain-free ROM by gradual adjustment of "percent range" and increase as tolerated.

- QUAD/HAM strengthening:
  - **Device**: Biodex Multi-Joint System
  - **Pattern**: Knee extension/flexion
  - **Setup**: 180 and 300 deg/sec
  - **Mode**: Isokinetic
  - **Sets and Reps**: 3 X 15
  - **Recommendations**: instruct patient to perform quad "set" Use clinical judgment to determine effort level In event of insufficient "set", Electro Neuromuscular Stimulation (ENS) may be used to stimulate contraction.

- **Device**: Biodex Closed Chain Attachment
  - **Setup**: 60 and 180 deg/sec
  - **Mode**: Isokinetic
  - **Sets and Reps**: 3 X 15
  - **Recommendations**: Set ROM from 0 to 45 degrees of flexion; focus on submaximal efforts to develop neuromuscular control of quadriceps and hamstrings.
SUPERVISED PROGRAM:

- Reduce swelling/edema and manage pain
- P.R.I.C.E.
- Cardiovascular conditioning
- Biodex Upper Body Cycle: progress toward 10 min. at target heart rate
- Muscle re-education (for disuse atrophy)
- Electrical muscle stimulation (EMS) as prescribed

HOME PROGRAM:

- Reduce swelling/edema and manage pain
- P.R.I.C.E.
- PROM exercises
- Patella mobilization: 5 min., 4 x/day (superior/inferior and medial/lateral glides)
- AAROM assisted knee extension: 3 x 10 reps, 4 x/day
- Pre-operative strengthening
- Quad set: 1 x 10 reps, 10 sec. hold, hourly
- Heel slide: 3 x 10 reps, 4 x/day
- Straight leg raise (SLR): 3 x 10 reps, 4 x/day
  - Hip flexion/extension and hip adduction/abduction
- Hamstring curls: 3 x 10 reps, 4 x/day
- Practice normal gait patterns

REPORTS:

- Biodex isokinetic bilateral comparison @ 60, 180 and 300 deg/sec
- Biodex isometric bilateral comparison @ 30 and 60°
- Biodex bilateral OKC proprioception test
- Biodex Balance System Bilateral and Unilateral stance
PHASE I

GOALS AND CRITERIA FOR ADVANCEMENT:

- Protect the graft
- Attain full passive extension
- Allow wound healing
- Reduce pain, effusion, swelling/edema
- Passive ROM: 0° > 90°
- Active ROM: 20°–70° (minimum)
- Avoid contractures
- Patellar mobility
- Ambulation: with 2 crutches (brace locked at 0°)
- Increase weight bearing as tolerated (WBAT) tolerance to full
- Perform quad set
- Isometric strength: Hamstring < 35% deficit
- Joint laxity: < 3 mm variance from uninvolved
  (AP displacement from uninvolved contralateral knee)

CONSIDERATIONS:

- Protect the graft - avoid sudden loads and excessive shear or strain to ACL - initially keep ROM below 40°
- Allow wound healing - avoid strenuous exercise in this phase
- Mobilize the patella to minimize contractures
- Achieve full extension to avoid flexion contracture block
CLINICAL EVALUATION:

- Verify home program compliance
- Pain scale: location, quality, duration, radiation, severity
- Hemarthrosis/effusion, swelling/edema: quantify and describe
  (Monitor any aspirations performed by physician)
- Palpate soft tissue in contracture-prone areas
- Patella: position, mobility and condition
- ROM: determine full active and passive ranges
- Quadriceps: quality of voluntary contraction
- Existence and description of spasm

Final visit of this phase

- TEST: Joint laxity bilaterally
  - Device: Arthrometer, 20 lb (89 N)
  - Report: compare to contralateral normal knee
- TEST: Bilateral isometric QUAD/HAM evaluation
  - Device: Biodex Multi-Joint System
  - Motion: knee EXT/FLEX
  - Report: Isometric Evaluation
  - Pad Placement: normal (distal)
  - Setup: HS @ 30°/60°, QU @ 60°
  - Mode: Isometric
  - Reps and Time: 5 @ 5 sec
  - Recommendation: instruct patient to generate as much force as they feel capable.

CLINICAL TREATMENT OPTIONS:

- Reduce swelling/edema and manage pain
- High-Volt Pulsed Electrical Stimulation (6-10 hrs/day) to decrease pain, stiffness and swelling
- Electrical stimulation of QUAD for maximal activation (if unable to perform SLR or reflex inhibition interferes with optimal voluntary contraction)
- Improve circulation and control hemarthrosis
- P.R.I.C.E.: Cryotherapy and compressive garment (neoprene or elastic) for reduction of pain and swelling/edema.
- Patellar mobilization (superior/inferior and medial/lateral glides 5 min 3x/day)
- Weight-bearing ambulation training with brace locked at 0°
- AAROM using Biodex BioStep® Semi-Recumbent Elliptical
  (Seat at highest setting. Instruct patient to work within pain free range of motion)
CLINICAL TREATMENT OPTIONS (cont):

- Passive and Active-assisted Range of Motion (PROM and AROM):
  \textbf{Device:} Biodex Multi-Joint System
  \textbf{Pattern:} Knee EXT/FLEX
  \textbf{Setup:} ROM Limits set to treatment goals [ideal - 0° and 90°]
  \textbf{Percent Range:} initial settings - 60% both directions
  \textbf{Mode:} Passive
  \textbf{Speed:} 2 deg/sec. initial setting (progress toward 10 deg/sec as tolerated)
  \textbf{Pause:} 10 sec hold each direction
  \textbf{Cushion:} 9
  \textbf{Duration:} 15 min.
  \textbf{Recommendations:} Do not strap patient to lever arm. Instruct patient not to resist in extension or flexion. Determine pain-free ROM by gradual adjustment of “percent range” dials. Utilize modalities to decrease discomfort. After first session, have patient perform “comfortable” concentric hamstring contractions in flexion.

- Quadriceps strengthening and disuse atrophy treatment \cite{6,15}
  \textbf{Device:} Biodex Multi-Joint System
  \textbf{Motion:} knee EXT
  \textbf{Setup:} 30°/60°/90°
  \textbf{Mode:} Isometric
  \textbf{Duration:} 1 x 10 reps x 10 sec hold
  \textbf{Recommendations:} In event of poor “set” and/or Patella infera, implement Electro Neuromuscular Stimulation (ENS) and/or surface electromyography (SEMG) biofeedback to facilitate higher motor unit activity. \cite{7,8}

- Quadriceps strengthening and disuse atrophy treatment
  \textbf{Device:} Biodex Multi-Joint System
  \textbf{Motion:} Closed Chain Attachment
  \textbf{Setup:} ROM limits set for 40° flexion to full extension \cite{27}
  \textbf{Mode:} Passive
  \textbf{Speed:} 5 deg/sec progress to 10 deg/sec
  \textbf{Duration:} 5 mins.
  \textbf{Recommendations:} Start in Passive mode and have patient do active assisted terminal extensions. Progress to isokinetic mode as strength increases - efforts should focus on neuromuscular control.

- Hamstring strengthening and disuse atrophy treatment
  \textbf{Device:} Biodex Multi-Joint System, knee flexion
  \textbf{Setup:} 15°/30°/45°/60°/75°/90°
  \textbf{Mode:} Isometric
  \textbf{Duration:} 2 x 5 reps x 5 sec hold, progress to 3 x 15 reps

  \textbf{Device:} Biodex Multi-Joint System
  \textbf{Motion:} active assisted knee flexion
  \textbf{Pad Placement:} distal
  \textbf{Setup:} ROM stop set up at passive end ROM
  \textbf{Mode:} Passive
  \textbf{Torque:}
  \textbf{Speed:} 30 and 60 deg/sec
  \textbf{Duration:} 3 x 10 reps
  \textbf{Recommendation:} Do not strap patient to lever arm. Instruct patient to apply force only with hamstrings and initially relax quadriceps. Gradually decrease torque in the direction of extension so to elicit a co-contraction of quads and hams at the point of terminal extension.

- Strengthening progression for hip/knee musculature:
  \textbf{Quad set:} at full extension (preferred) or at comfortable flexed position (seated)
  - 10 x 10 sec. hold
  \textbf{Straight leg raise (SLR):} hip EXT/FLEX with knee at 0°
  - 3 sets x 10 reps (Electro Neuromuscular Stimulation (ENS) to quadriceps as needed to improve contractions)
  \textbf{Hip ABD/ADD (SLR)}
  - 3 sets x 10 reps (add weights as tolerated)
  \textbf{Standing Hamstring curls}
  - 3 sets x 10 reps (add weights as tolerated)
SUPERVISED PROGRAM:

- Reduce spasm, pain and swelling/edema
- Cardiovascular Conditioning
  - Biodex Upper Body cycling
  - 60%-80% MHR for > 10 min
- Muscle re-education strengthening exercises for disuse atrophy
  - Quad sets, SLR, etc.

HOME PROGRAM:

- Reduce spasm, pain, and swelling/edema using P.R.I.C.E.
- Patellar mobilizations [superior/inferior and medial/lateral glides 5 min 3x/day]
- Ankle pumps 5 min hourly
- CPM: 0º-90º for 8-10 hr/24 hr period
- Passive and active assisted range of motion exercises
  - Prone hangs for 10-15 min.
  - Heel slides
  - Seated active assisted knee extensions (uninvolved limb supporting involved)
- Non-weight-bearing muscle control and strengthening exercises
  - Quad sets
  - Straight leg raises
  - Hamstring sets
  - Standing knee flexion (progressing to weight resisted)

REPORTS:

- Analog pain scale
- Cardiovascular fitness level
- Biodex isometric bilateral comparison
  - QUAD @ 60º and HAM @ 30º
- Tibial AP displacement: involved/uninvolved

PHASE I: REDUCTION OF ACUTE SYMPTOMS
GOALS AND CRITERIA FOR ADVANCEMENT:

- Protect the graft
- AROM: 0°-90° (minimum)
- PROM: 0°-115°
- Wound healing (remove sutures)
- Control swelling/edema
- Pain controlled without narcotics
- Ambulation: with 1 crutch
  [brace locked at 0°)
- Full Weight-bearing
- Isometric strength:
  QUAD < 60% deficit
  HAM < 25% deficit
- Joint Laxity:
  < 2 mm variance from uninvolved
  < 2 mm change from previous measurement of involved

CLINICAL EVALUATION:

- Verify home program compliance
- Pain scale: location, quality, duration, radiation, and severity.
  [Evaluate pain through ROM and at end ranges] 15
- Hemarthrosis/Effusion: quantify and describe 15
  [Monitor any aspirations performed by physician]
- Palpate soft tissue in contracture-prone areas
- Existence and description of spasm
- Patella: position, mobility and condition
- ROM: determine full active and passive ranges
- TEST: Quadriceps control
  Quality of voluntary contraction at multiple angles (to include terminal extension) 15

All tests are on final visit of this phase
CLINICAL EVALUATION (cont):

- TEST: Joint laxity: Tibial displacement bilaterally
  - Device: Arthrometer, 20 lb (89 N)
  - Report: Compare to contralateral normal knee
  - Total change from post-op
  - Change from previous test

- TEST: Bilateral isometric evaluation
  - Device: Biodex Multi-Joint System, knee EXT/FLEX
  - Report: Isometric Evaluation
  - Setup: HS @ 30°/60°, QUAD @ 60°
  - Mode: Isometric
  - Reps and Time: 5 @ 5 sec
  - Recommendation: instruct patient to generate as much force as they feel capable.
CLINICAL TREATMENT OPTIONS:

- Reduce swelling/edema and manage pain
- High-Volt Pulsed Electrical Stimulation (6-10 hrs/day) to decrease pain, stiffness and swelling
- Electrical stimulation for atrophy as needed
- Improve circulation and control Hemarthrosis
- P.R.I.C.E.: Cryotherapy and compressive garment for reduction of pain and swelling
- Patellar mobilization (superior/inferior and medial/lateral glides 5 min 3x/day)
- Full Weight-bearing ambulation
- Ambulation training with brace locked at 0°
- Flexibility:
  - Hamstrings, hip flexors and lower leg musculature
  - Static hold stretch: 3 x 20-30 sec hold
- Passive and Active-Assistive Range of Motion (PROM and AAROM):
  - **Device**: Biodex Multi-Joint System
  - Motion: knee EXT/FLEX
  - Setup: ROM Limits set to treatment goals (ideal - 0° and 115°)
  - Percent Range: initial settings – 70-80% both directions
  - Mode: Passive
  - Speed: 20 deg/sec. initial setting (progress toward 40 deg/sec. as tolerated)
  - Pause: 10 sec hold each direction
  - Cushion: 9
  - Duration: 5 min. (progress towards 15 min.)
  - Recommendations: Instruct patient to not actively contract quad. Determine pain-free ROM by gradual adjustment of “percent range” dials. Utilize modalities to decrease discomfort. Have patient contract hamstrings concentrically in flexion and to do a “Quad set” while paused in full extension.

- Stationary cycling initiated when knee flexion is > 90° flexion:
  - **Device**: Biodex BioStep® Semi-Recumbent Elliptical
  - **NOTE**: Total work recorded for each session)
  - Mode: Isokinetic
  - Speed: Gradual decrease to 60 RPM as capable. (Should initiate at high RPMs to reduce resistance)
  - Duration: 5-15 min.
  - Recommendation: Increase seat height to accommodate limited knee flexion ROM.

- Quadriceps strengthening and disuse atrophy treatment:
  - **Device**: Biodex Multi-Joint System
  - Motion: knee extension
  - Setup: 30°/60°/90°
  - Mode: Isometric
  - Duration: 10 sec. x 10 reps x 1 set
  - Recommendations: In event of poor “set” and/or Patella infera, implement Electro Neuromuscular Stimulation (ENS) and/or surface electromyography (SEMG) biofeedback to facilitate higher motor unit activity.

- Quadriceps strengthening and disuse atrophy treatment:
  - **Device**: Biodex Multi-Joint System
  - Motion: Closed Chain Attachment
  - Setup: ROM limits set for 40 deg flexion to full extension
  - Mode: Passive
  - Speed: 20 deg/sec (progress towards 40°)
  - Sets and Reps: 3 x 10
  - Recommendations: Instruct patient to perform tolerable concentric quadriceps contractions in extension and to relax in flexion.
CLINICAL TREATMENT OPTIONS (cont):

- **Hamstring strengthening:**
  - **Device:** Biodex Multi-Joint System
  - **Motion:** knee flexion
  - **Setup:** 15°/30°/45°/60°/75°/90°
  - **Mode:** Isometric
  - **Duration:** 5 sec. x 10 reps x 2 sets each

- **Device:** Biodex Multi-Joint System
  - **Motion:** Active-assisted knee flexion
  - **Setup:** ROM stop set up at passive end ROM
  - **Mode:** Passive
  - **Speed:** Direction of flexion 180 and 300 deg/sec
  - **Direction of extension:** 30 deg/sec
  - **Set and Reps:** 3 x 10
  - **Recommendation:** Instruct patient to contract the hamstrings and to relax the quadriceps.

- **Proprioception Neuromuscular Facilitation (PNF)**
  - **PNF patterns D1/D2:** 5 x 10-30 sec.

- **Hip strengthening:** SLR with 5 lb hip flex/ext and abd/add with knee at 0°
  - **3 x 10 reps** (Electro Neuromuscular Stimulation [ENS] to quadriceps as needed to improve contractions)

- **Non-weight-bearing Proprioception:**
  - **Device:** Biodex Multi-Joint System
  - **Pattern:** Knee EXT/FLEX
  - **Mode:** Passive and Isokinetic
  - **Sets and Reps:** 3 x 10 each target angle
  - **Hold:** 10 seconds
  - **Target angles:** 90°/60°/30°
  - **Recommendations:** There should be no incidence of pain or inhibition with movement.
SUPERVISED PROGRAM:

- Reduce spasm, pain and swelling/edema
- Cardiovascular Conditioning
  Biodex Upper Body cycling progressing to 20 min at 60%-80% MHR
- Strengthening exercises for hip, knee and lower leg
  Quad sets: 10 cycles x 15 sec. contraction, 10 sec. relaxation
  SLRs: hip add/abd and flex/ext. with 5 lb weight: 3 x 10 reps each direction
  Standing Leg curls with 5 lb weight: 3 x 10 reps
  Calf raises: bilateral stance, 3 x 10 reps
- Flexibility of hamstrings, hip flexors and lower leg musculature
  Static hold stretch: 3 x 20-30 sec hold

HOME PROGRAM:

- Reduce spasm, pain, and swelling/edema using P.R.I.C.E.
- Patellar mobilizations (superior/inferior and medial/lateral glides 5 min 4x/day)
- Ankle pumps 5 min hourly
- CPM: 0-90° for 8-10 hr/24 hr period (if Active ROM < 0 – 90 deg).
- PROM and AAROM exercises
  Prone hangs for 10-15 min.
  Heel slides
  Seated active assisted knee extensions (uninvolved limb supporting involved)
- Non Weight-bearing (NWB) muscle control and strengthening exercises
  Quad sets: 10 cycles, 15 sec. contraction, 10 sec relaxation (hourly)
  SLR
  Standing knee flexion
- Flexibility of hamstrings, hip flexors and lower leg musculature.
  Static hold stretch: 3 x 20-30 sec hold

REPORTS:

- Analog pain scale
- Cardiovascular fitness level
- Biodex Balance System bilateral stance
- Biodex isometric bilateral comparison QUAD/HAM @ 60°
- Tibial AP displacement: involved/uninvolved
PHASE III

initial weight-bearing & intermediate strengthening

GOALS AND CRITERIA FOR ADVANCEMENT:

- Protect the graft
- AROM: $0^\circ > 125^\circ$
- PROM: $0^\circ > 135^\circ$
- Pain-free through full ROM during activities of daily living (ADLs)
- Effusion and swelling/edema: none
- Ambulation: unassisted
- Maintain FWB
- Laxity
  - $< 2\text{mm}$ (at 20 lb) variance from uninvolved knee.
  - $< 2\text{mm}$ (at 20 lb) variance from previous measurement.
- Stability Index: 70% of Normative value for bilateral stance.
- Strength:
  - Quadriceps $< 40\%$ deficit
  - Hamstrings $< 20\%$ deficit
  - Ham/Quad ratio $> 80\%$

CLINICAL EVALUATION:

- Verify home program compliance
- Pain scale: location, quality, duration, radiation, and severity
  (If continuous, diffuse limb pain persists, evaluate for RSD)
- Hemarthrosis/Effusion: quantify and describe
  (Monitor any aspirations performed by physician)
- Palpate soft tissue in contracture-prone areas
- Patella: position, mobility and condition
- ROM: determine full AROM and PROM
- Existence and description of spasm
**CLINICAL EVALUATION (cont):**

- **TEST: Quadriceps control**
  
  Quality of voluntary contraction at multiple angles (to include terminal extension).  

  All tests are on final visit of this phase

- **TEST: Joint laxity bilaterally**

  **Device:** Arthrometer, 20 lb (89 N)

  **Report:** Compare to contralateral normal knee

  Total change from post-op

  Change from previous test

- **TEST: Bilateral isometric QUAD/HAM evaluation**

  **Device:** Biodex Multi-Joint System

  **Motion:** knee EXT/FLEX

  **Report:** Isometric Evaluation

  **Setup:** HS @ 30º/60º; QUAD @ 60º

  **Mode:** Isometric

  **Reps and Time:** 5 @ 5 sec

  **Recommendation:** Instruct patient to generate as much force as they feel capable.

- **TEST: Bilateral isokinetic QUAD/HAM 2 speed evaluation**

  **Device:** Biodex Multi-Joint System

  **Motion:** knee EXT/FLEX

  **Report:** Isokinetic Evaluation – 2 speeds

  **ROM:** 110-40º

  **Setup:** 180 and 300 deg/sec

  **Sets and Reps:** 1 x 10 at 180 deg/sec and 1 x 15 at 300 deg/sec

  **Recommendation:** Limit ROM from full flexion (approx. 110º) to 40º extension

- **TEST: Gait evaluation**

  **Device:** Biodex Gait Trainer

  **Report:** Exercise Summary

  **Speed:** comfortable for patient

  **Time:** 6 min or until tolerance

  **Elevation:** 0%

  **Recommendations:** Gradually increase speed and duration of walking with proper gait. Emphasis on proper foot progression angle. Biodex Unweighing System can be used to increase patient safety.

- **TEST: Bilateral stability**

  **Device:** Biodex Balance System

  **Report:** Stability Index

  **Stance:** Bilateral (Both feet)

  **Setup:** Dynamic Balance

  **Stability level:** 8 (most stable)

  **Duration:** 5 trials of 20 sec, with 30 sec rest between trials
CLINICAL TREATMENT OPTIONS:

- Control inflammation, swelling/edema and pain. High-Volt Pulsed Electrical Stimulation (6-10 hrs/day) to decrease pain, stiffness and swelling

- Improve circulation and control Hemarthrosis

- Protect, Rest, Ice, Compression and Elevate (P.R.I.C.E.):
  - Cryotherapy and compressive garment for reduction of pain and swelling

- Patellar mobilization (superior/inferior and medial/lateral glides 5 min 3x/day)

- Full Weight-bearing (FWB) ambulation

- Ambulation training with brace locked at 0º

- Electrical stimulation for atrophy as needed

- Flexibility of hamstrings, hip flexors and lower leg musculature
  - Static hold stretch: 20-30 sec hold for 3 reps

- Passive and Active-assisted Range of Motion (ROM):
  - This should be done as needed should the patient exhibit poor ROM
  - **Device:** Biodex Multi-Joint System
  - Motion: knee EXT/FLEX
  - Setup: ROM Limits set to treatment goals (ideal – 0º and 115º)
  - Percent Range: initial settings – 70-80% both directions
  - Mode: Passive
  - Speed: 10 deg/sec. initial setting (progress toward 20 deg/sec as tolerated)
  - Pause: 5 sec hold each direction
  - Duration: 10 min. (progress towards 15 min.)
  - Recommendations: Strapping patient to lever arm is optional. Instruct patient not to exert force in extension. Determine pain-free ROM by gradual adjustment of “percent range” dials. Utilize modalities to decrease discomfort. Have patient contract hamstrings concentrically in flexion and to do a “Quad set” during pause in full extension.

- Stationary cycling:
  - **Device:** Biodex BioStep® Semi-Recumbent Elliptical
  - Mode: Isokinetic
  - Speed: Gradual decrease to 60 RPM as capable
  - Duration: 15 min

- Weight-bearing Prorioception:
  - **Device:** Biodex Balance System
  - Stance: Bilateral (Both feet)
  - Setup: Dynamic Balance
  - Stability level: 8 (most stable) progressing to 4 (less stable)
  - Duration: 5 bouts of 30 sec (progressing to 10 bouts)

- Non-weight-bearing proprioception:
  - **Device:** Biodex Multi-Joint System
  - Passive and Active Joint position sense
  - Pattern: Knee EXT/FLEX
  - Mode: Passive and Isokinetic
  - Sets and Reps: 3 x 5 each target angle
  - Hold: 10 seconds
  - Target angles: 90º/75º/60º/45º/30º/15º/0º
  - Recommendations: There should be no incidence of pain or inhibition with movement
• Quadriceps strengthening and disuse atrophy treatment:
  
  **Device**: Biodex Multi-Joint System
  
  **Motion**: knee extension
  
  **Setup**: 30º/60º/90º
  
  **Mode**: Isometric
  
  **Duration**: 1 x 10 reps x 10 sec each speed
  
  **Recommendations**: In event of poor “set” and/or Patella infera, implement Electro Neuromuscular Stimulation (ENS) and/or surface electromyography (SEMG) biofeedback to facilitate higher motor unit activity.
  
  **Device**: Biodex Multi-Joint System
  
  **Attachment**: Closed Chain Attachment
  
  **Setup**: ROM limits set for 40º flexion to full extension (footnote)
  
  **Mode**: Passive, Isokinetic (Con/Ecc)
  
  **Speed**: 40 deg/sec (progress towards 60º)
  
  **Duration**: 3 x 10 reps
  
  **Recommendations**: Isokinetic Mode Con/Ecc can be used as a precursor to gait training as it mimics the muscle control required for stepping.
  
• Hamstring strengthening:
  
  **Device**: Biodex Multi-Joint System
  
  **Motion**: knee flexion
  
  **Setup**: 30 and 60 deg/sec
  
  **Torque settings**: 10 ft-lb
  
  **Mode**: Passive
  
  **Duration**: 2 x 10 reps
  
  **Recommendations**: Instruct patient to contract hamstrings with flexion and to resist with hamstrings into extension. Eccentric contraction should be sub-maximal with smooth movement.
  
  **Device**: Biodex Multi-Joint System
  
  **Motion**: active assisted knee flexion
  
  **Setup**: ROM stop set up at passive end ROM
  
  **Mode**: Passive
  
  **Speed**: Direction of flexion 180 and 300 deg/sec
  
  **Direction of extension** 30 deg/sec
  
  **Duration**: 2 x 10 reps
  
  **Recommendation**: Instruct patient to apply force only with hamstrings and to relax quadriceps.
  
• Hip strengthening: SLR with 5 pounds: hip flex/ext and abd/add with knee at 0º
  
  3 sets x 10 reps (Electro Neuromuscular Stimulation (ENS) to quadriceps as needed to improve contractions)
  
• Muscle re-education for disuse atrophy: 5 Electrical muscle stimulation (EMS) as prescribe
  
• Address Gait Abnormalities
  
  **Device**: Biodex Gait Trainer
  
  **Speed**: Very slow, comfortable for patient
  
  **Elevation**: 0%
  
  **Duration**: Progress to 20 min, as tolerated
  
  **Recommendations**: Low-speed treadmill walking with Unweighing System as needed. Gradually increase speed and duration of walking with proper gait.
SUPERVISED TREATMENT OPTIONS:

- Manage pain and swelling/edema
  PR.I.C.E.

- Strengthening:
  **Device**: Multi-Exercise Weight Machine
  Motion: Knee extension (quadriceps) Isotonic progressive resistance exercise (PRE)  
  Range Limit: set to block extension at 40°
  Resistance (initial): plate #2; 10 lb (4.5 kg)
  Duration: 3 x 10 reps
  Instructions: starting at 90°, perform slow extension while concentrating on co-contracting quads and hams through ROM. Knee flexion (hamstrings) Isotonic PRE
  Pad Placement: distal
  Resistance: 50% of maximum capability
  Duration: 3 x 10 reps

  Weight-bearing exercises:
  Pattern: Squats
  Setup: ROM controlled for knee range from 0° to 30°
  Resistance: Initially minimal, progress toward FWB (unilaterally)
  Duration: 3 x 20 reps
  Instructions: For terminal extension with minimal ACL stress
  Lateral step-up: 4 in. (10 cm) level, 3 sets of 30 sec. cycles

- Hip Endurance:
  Hip FLEX/EXT and ABD/ADD Isotonic PRE
  Resistance: Low resistance
  Duration: 3 x 30 reps
  Instructions: Sub-maximal effort.
  Pool walking: 20 min.

- Single-leg calf raise: (when weight-bearing = 100% body weight)
  Progress toward 3 x 45 reps. Then, exercise is done on step: 3 x 20 reps.
  Stretch calf musculature before and after exercise.

- Proprioceptive Neuromuscular Facilitation:
  PNF patterns D1/D2: 10-30 sec., 5 times

- Stabilization training: (when weight-bearing = 100% BW)
  Side-to-side and backward-to-forward weight shift (no crutch): 10 min

- Cardiovascular conditioning:
  **Device**: Biodex Upper Body Cycle
  Duration: 20 min. at target heart rate
HOME PROGRAM:

- Pain/swelling/edema control:
  PR.I.C.E.

- Patella mobilization:
  Medial/lateral and superior/inferior glide: 5 min., not less than 4 times/day

- Range of motion activities:
  Active-assisted knee EXT/FLEX (quads), 30-90°
  3 x 10 reps, 3 x/day

- Muscle control:
  Quad set: 10 reps x 10 sec. hold, hourly
  Adductor set: 3 sets x 10 reps x 10 sec. hold

- Strengthening (hip, knee, and calf musculature):
  SLR (with resistance as tolerated): 3 x 30, 3 x/day
  Hip EXT/FLEX, ABD/ADD
  Hamstring curl: 3 x 10 reps, 3 x/day
  Heel slide: 3 x 10 reps, 3 x/day
  Mini-squat: 3 x 10 reps, 3 x/day
  Single-leg calf raise (when WB = 100% BW):
  Progress toward 3 sets x 40 reps, 3 x/day - then, same exercise is done on step
  Stretch calf musculature before and after exercise

- Flexibility: (static hold stretch)
  3 reps x 15-20 sec. hold, 3 x/day
  Hamstrings
  Hip flexors
  Gastrocnemius/Soleus

REPORTS:

- Analog pain scale
- Cardiovascular fitness level
- Biodex Balance System bilateral stance Stability Index
- Biodex isometric bilateral comparison QUAD @ 60°; HAM @ 30°
- Biodex isokinetic bilateral comparison QUAD/HAM 110-40° @ 300 deg/sec
- Biodex Gait Trainer evaluation
- Tibial AP displacement:
  Involved compared to uninvolved
  Change in involved from previous test
  Total change in involved from first test
PHASE IV

GOALS AND CRITERIA FOR ADVANCEMENT:

- Protect the graft
- Active ROM: 0° > 125°
- Passive ROM: 0° > 135°
- Pain-free through full ROM during activities of daily living (ADLs)
- Effusion: none
- Maintain full AROM and PROM
- Maintain full FWB
- Ambulation: unassisted, equal step length and time distribution uninvolved to involved
- Laxity
  - < 3mm (at 20 lb) variance from uninvolved knee
  - < 2mm (at 20 lb) variance from previous measurement
- Stability Index: 80% of Normative value for bilateral stance
- Strength:
  - Quadriceps < 35% deficit
  - Hamstrings < 6% deficit
  - Ham/Quad ratio > 85%

CLINICAL EVALUATION:

- Verify home program compliance
- Pain scale: location, quality, duration, radiation, and severity
  (If continuous, diffuse limb pain persists, evaluate for RSD)
- Hemarthrosis/Effusion:
  - Quantify and describe
  - Monitor any aspirations performed by physician
- Palpate soft tissue in contracture-prone areas, note any existence and description of spasm
- Patella: position, mobility and condition
- ROM: AROM and PROM limits
- TEST: Quadriceps control
  - Quality of voluntary contraction at multiple angles (to include terminal extension)
  - Test every other week and final visit
CLINICAL EVALUATION (cont):

- **TEST**: Joint laxity bilaterally 5
  
  **Device**: Arthrometer, 20 lb [89 N] 6
  
  **Report**: Compare to contralateral normal knee
  
  Total change from post-op
  
  Change from previous test

- **TEST**: Bilateral isometric QUAD/HAM evaluation
  
  **Device**: Biodex Multi-Joint System, knee EXT/FLEX
  
  **Report**: Isometric Evaluation
  
  Pad Placement: normal [distal]
  
  Setup: HAM @ 30º/60º, QUAD @ 60º
  
  **Mode**: Isometric
  
  **Reps and Time**: 5 @ 5 sec
  
  **Recommendation**: Instruct patient to generate as much force as they feel capable.

- **TEST**: Bilateral isokinetic QUAD/HAM 2 speed evaluation
  
  **Device**: Biodex Multi-Joint System, knee EXT/FLEX
  
  **Report**: Isokinetic Evaluation – 2 speeds
  
  Pad Placement: proximal
  
  **ROM**: 110º-40º 27
  
  Setup: 180 and 300 deg/sec
  
  **Sets and Reps**: 1 x 10 reps each speed

- **TEST**: Gait evaluation 15
  
  **Device**: Biodex Gait Trainer
  
  **Report**: Exercise Summary
  
  Speed: comfortable for patient.
  
  Time: 6 min or until tolerance
  
  Elevation: 0%
  
  **Recommendations**: Gradually increase speed and duration of walking with proper gait. Emphasis on proper foot progression angle. Biodex Unweighing System can be used to increase patient safety

  Test final visit this phase

- **TEST**: Bilateral stability
  
  **Device**: Biodex Balance System
  
  **Report**: Stability Index
  
  **Stance**: Bilateral (Both feet)
  
  **Setup**: Dynamic Balance
  
  **Stability level**: 8 (most stable)
  
  **Duration**: 5 trials of 20 sec, with a 30 sec rest between trials
CLINICAL TREATMENT OPTIONS:

- Reduce swelling/edema and manage pain, High-Volt Pulsed Electrical Stimulation as needed to decrease pain, stiffness and swelling.

- Patellar mobilization (superior/inferior and medial/lateral glides 5 min 4x/day)

- Active-Assistive Range of Motion (AAROM): until Active Range of Motion (AROM) is pain-free

- Flexibility of hamstrings, hip flexors and lower leg musculature:
  
  Static hold stretch: 20-30 sec hold for 3 reps

- Quadriceps Strengthening and Conditioning:
  
  **Device:** Multi-Exercise Weight Machine
  
  Motion: knee extension (concentric and eccentric)
  
  Range Limit: set to block extension at 40°
  
  Resistance: progress from Phase III based on clinical judgment if no pain, swelling, or crepitus after exercise
  
  Duration: 3 x 10 reps
  
  Instructions: Work range 90°- 30° at approx. 60 deg/sec
  
  Lateral step-up: 4 in. (10 cm) level, 3 sets of 30 sec. cycles

  **Device:** Biodex Multi-Joint System
  
  Attachment: Closed Chain Attachment
  
  Setup: ROM limits set for 40° flexion to full extension
  
  Mode: Isokinetic
  
  Speed: 60 deg/sec
  
  Sets and Reps: 3 x 10 reps

  **Device:** Biodex Multi-Joint System
  
  Motion: knee EXT/FLEX
  
  Mode: Isokinetic
  
  Setup: ROM limits 110°- 40°
  
  Speed: 180 and 300 deg/sec
  
  Sets and Reps: 2 x 10 each speed

- Hamstring Strengthening and Conditioning PRE:
  
  **Device:** Multi-Exercise Weight Machine
  
  Motion: hamstrings (concentric and eccentric)
  
  Resistance: 50% of maximum capability
  
  Duration: 3 x 10 reps (progress toward 5 x 15 reps)

- Hamstring Strengthening and Conditioning PRE:
  
  **Device:** Biodex Multi-Joint System
  
  Motion: knee flexion
  
  Speed: Direction of flexion 60, 180 deg/sec
  
  Direction of extension 30 and 60 deg/sec
  
  Torque settings: 30 ft-lb, increase as needed
  
  Mode: Isokinetic CON/ECC
  
  Duration: 2 x 10 reps
  
  Recommendations: Instruct patient to contract hamstrings with flexion and to resist with hamstrings into extension. Eccentric contraction should be sub-maximal.

- Co-contraction Training:
  
  **Device:** Slide board or Fitter
  
  Duration: 3 x 20 sec (progress to 30 sec)

  **Device:** Vertical Squat
  
  Duration: 3 x 10 reps
  
  ROM: Limit to 40° flexion to full extension
  
  Recommendations: May use Theraball against wall for support
- **Isokinetic endurance training (quadriceps)**
  
  **Device:** Biodex Multi-Joint System  
  Motion: knee extension  
  Setup: ROM limit extension at 30° (progress toward 20°)  
  Mode: Isokinetic  
  Speeds (both directions): 180-240 deg/sec  
  Duration: 3 x 20 (progress towards 30 reps), 3 x/week  
  Recommendations: Instruct patient to work at 70% of maximum effort.

- **Weight-bearing proprioception:**
  
  **Device:** Biodex Balance System  
  Stance: Unilateral  
  Level: Level 2 progressing to Level 1  
  Sets and Duration: 3 x 30 seconds (progress to 3 min continual)  
  Eyes: Closed  
  Training method: Trace circles on screen (A-D), color in circles (A-B)  
  Recommendations: Have patient progress to using no hands

- **Non-weight-bearing proprioception:**
  
  **Device:** Biodex Multi-Joint System  
  Passive and Active position sense  
  Pattern: Knee EXT/FLEX  
  Mode: Passive and Isokinetic  
  Sets and Reps: 3 x 5 each target angle  
  Hold: 10 seconds  
  Target angles: 90°/75°/60°/45°/30°/15°/0°  
  Recommendations: There should be no incidence of pain or inhibition with movement.

- **Proprioceptive Neuromuscular Facilitation (PNF)**
  
  Hamstring PNF patterns at 30°- 0° flexion

- **Orthosis:**  
  Consider readjustment of brace to progressively increase flexion during ambulation.  
  Use clinical judgment after evaluating all contributing factors.  
  Discontinue use of knee brace when following criteria are met:  
  1. Laxity test remains stable 4 weeks into aerobic conditioning program  
  2. Patient experiences no giving way when out of brace  
  3. Clinical judgment based on objective measures of strength and balance  
  Recommend use under specified (elevated risk) circumstances.
SUPERVISED PROGRAM:

- **Gait Training:**
  
  **Device:** Biodex Gait Trainer
  
  Motion: uphill and retrograde walking:
  
  Speed: Very slow initially and increase based on clinical judgment
  
  Elevation: 0% initially, increase based on clinical judgment
  
  Duration: Progress to 20 min in each direction
  
  Recommendations: Gradually increase speed and duration of walking with proper gait. Encourage symmetrical step length, equal time distribution, and proper cycle time.

- **Isotonic Strengthening and Conditioning:**
  
  Seated (quadriceps) knee extension
  
  ROM: 90º to 30º of extension
  
  Resistance: continue to increase as tolerated
  
  Duration: 3 x 10 reps
  
  Seated (hamstrings) knee flexion
  
  ROM: Full
  
  Resistance: 50% of maximum capability
  
  Duration: 3 x 10 reps (progress toward 5 x 15 reps)
  
  Hip flexion, extension, abduction, and adduction
  
  Resistance: sub maximal effort, low resistance
  
  Duration: 3 x 30 reps
  
  Closed chain exercise (for terminal extension with minimal ACL stress)
  
  Setup: ROM controlled for knee range from 30º to 0º
  
  Resistance: progress toward BW equivalent (unilateral)
  
  Duration: 3 x 20 reps
  
  Single-leg calf raise:
  
  Setup: exercise is done on step
  
  Duration: 3 x 45 reps
  
  Stretch calf musculature before and after exercise

- **Endurance:**
  
  Pool walking: 20 min

- **Cardiovascular conditionings upper body cycling**
  
  **Device:** Biodex Upper Body Cycle
  
  Duration: 20 min at target heart rate
HOME PROGRAM:

- Pain/swelling/edema control
  PR.I.C.E.

- Strengthening (hip, knee, and calf musculature)
  SLR (with resistance as tolerated):
  - Hip EXT/FLEX ABD/ADD: 3 x 30 reps, 3 x/day
  - Hamstring curl: 3 x 10 reps, 3 x/day
  - Heel slide: 3 x 10 reps, 3 x/day
  - Mini-squat: 3 x 10 reps, 3 x/day
  - Single-leg calf raise on step: 3 x 40 reps, 3 x/day
  (Stretch calf musculature before and after exercise)

- Flexibility (static hold stretch): 3 x 15-20 sec. hold, 3 x/day
  - Quadriceps
  - Hamstrings
  - Hip flexors
  - Gastrocnemius /Soleus

- Patellar mobilization
  Superior/inferior and medial/lateral glides: 5 min 3x/day

REPORTS:

- Analog pain scale

- Cardiovascular fitness level

- Biodex Balance System bilateral and single leg stance
  Stability Index

- Biodex isometric bilateral comparison QUAD/HAM @ 60°

- Biodex isokinetic bilateral comparison QUAD/HAM 110°-45° @ 180 and 300 deg/sec

- Tibial AP displacement:
  Involved compared to uninvolved
  Change in involved from previous test
  Total change in involved from first test
PHASE V
advanced strengthening

GOALS AND CRITERIA FOR ADVANCEMENT:

- Protect the graft
- Maintain pain-free ADLs
- Maintain full active and passive ROM
- Maintain full FWB
- Laxity < 3mm (at 20 lb) variance from uninvolved knee
- Stability Index:
  95% of Normative Value* for bilateral stance
  85% of Normative Value for unilateral stance
- Strength:
  Quadriceps < 30% deficit
  Hamstrings < 4 % deficit
  QUAD/HAM ratio > 82%
- OKC Proprioception:
  Active < 15% deficit bilaterally
  Passive < 15% deficit

CLINICAL EVALUATION:

- Pain scale: location, quality, duration, radiation, and severity.
  (If continuous, diffuse limb pain persists, evaluate for RSD)
- Hemarthrosis/Effusion: quantify and describe
  (Monitor any aspirations performed by physician)
- Palpate soft tissue in contracture-prone areas
- Patella: position, mobility and condition
- Range of Motion (ROM): Active Range of Motion (AROM) and Passive Range of Motion (PROM) limits
- Existence and description of spasm
- Verify home program compliance
- TEST: Joint laxity bilaterally
  Frequency: Every 3rd week and last visit this phase.
  Device: Arthrometer, 20 lb (89 N) and 30 lb (134 N)
  Report: Compare to contralateral normal knee
  Total change from post-op
  Change from previous test
CLINICAL EVALUATION (cont):

- TEST: Bilateral isokinetic QUAD/HAM 2 speed evaluation
  Frequency: Every 4th week and last visit this phase
  Device: Biodex Multi-Joint System
  Motion: knee EXT/FLEX
  Report: Isokinetic Evaluation – 2 speeds
  ROM: 110º-40º
  Setup: 180 deg/sec and 300 deg/sec
  Sets and Reps: 1 x 10 reps each speed
  Recommendation: May begin full ROM testing at 300 deg/sec if clinically indicated.

- TEST: Unilateral stability
  Frequency: 6th and last visit this phase
  Device: Biodex Balance System
  Report: Stability Index
  Stance: Unilateral (single leg)
  Setup: Dynamic Balance
  Stability level: 8 (most stable) progressing to 6 (less stable)
  Duration: 5 bouts of 30 sec

- TEST: OKC Proprioception
  Frequency: 6th and last visit this phase
  Device: Biodex Multi-Joint System
  Active [muscle mechanoreceptor]
  Passive [joint capsule mechanoreceptor]
CLINICAL TREATMENT OPTIONS:

- Reduce swelling/edema and manage pain
- Patellar mobilization (superior/inferior and medial/lateral glides 5 min 3x/day)
- High-Volt Pulsed Electrical Stimulation (6-10 hr/day) to decrease pain, stiffness and swelling
- Active-Assistive Range of Motion (AAROM): until Active Range of Motion (AROM) is pain-free
- Flexibility of hamstrings, hip flexors and lower leg musculature

**Quadriceps Strengthening and Conditioning:**

Device: Biodex Multi-Joint System  
Motion: knee extension  
Mode: Isokinetic  
Range Limit: Full  
Speed: 300-500 deg/sec  
Duration: 3 x 20 reps  

Isotonic Leg Press PRE's  
Range: Not to exceed 90º of flexion  
Duration: 3 x 10 reps

**Hamstring Strengthening and Conditioning:**

Device: Biodex Multi-Joint System  
Motion: knee flexion  
Mode: Isokinetic  
ROM: Full  
Muscle contraction: ECC/CON  
Speeds: 60/90/120 deg/sec away direction  
60/180/300 deg/sec towards direction  

Retrograde Stair climbing:  
Duration: 10 min

Front Lunges:  
Duration: 3 x 10-15 reps

**Co-contraction Training:**

Vertical squats: 3 x 10-15 reps*  
Lateral lunges: 3 x 10-15 reps*  
Single leg squats: 3 x 10-15 reps  

* ROM: full extension to 60º flexion

**Plyometrics:**

Begin when stability and strength goals for Phase V are attained and patient can successfully perform closed-chain exercise and minimal impact running.  
Setup: Jump on/off 4 in. high platform, bilateral stance, rapid succession, no pauses  
Sets and Reps: 3 x 15-20 reps (progress toward 30 reps)  
Progress: Increase to 8-10 in. step over period of 3-4 weeks  
Recommendation: Add bounding, rope-skipping, trampoline jumping. Start with low reps and sets - progress based on clinical judgments

**Weight-bearing Proprioceptive Training:**

Continue program, demanding more strength, power, and endurance. Add functional activity drills such as semi-circular running and backward running  
Device: Biodex Balance System  
Stance: Unilateral (single leg)  
Setup: Dynamic Balance  
Stability level: 8 progress to level 6  
Duration: 5 bouts of 30 sec (progressing to 10 bouts)
SUPERVISED PROGRAM:
(Frequencies prescribed on individual basis)

- **Strengthening and Conditioning**
  
  **Isotonics:**
  
  - Continue open and closed-chain programs.  
  - Progressively increase resistance, maintaining effort level at 70-75% of maximum
  - Give consideration to patient's tolerance and activity goals
  - Seated knee extension (quadriceps): 90°-30°
  - Seated knee flexion (hamstrings): full ROM
  - Closed chain terminal knee extension: 30°-0°
  - Cable column with strap around distal thigh (pulley at same height)
  - Leg press
  - Hip flexion, extension, abduction, and adduction
  - Single-leg calf raises
  
  **Plyometrics:**
  
  - Jump on/off 4 in. high platform, bilateral stance, rapid succession, and no pauses
  - Sets and Reps: 15-20 reps, 3 sets (progress toward 30 reps)
  - Progression: 8-10 in. step over period of 3-4 weeks - then add bounding, rope-skipping, trampoline jumping.
  - Start with low reps, sets - progress based on clinical judgments

- **Cardiovascular conditioning**
  
  **Device:** Biodex Upper Body Cycle
  **Mode:** Cardiac
  **Duration:** 20 min at target heart rate

  **Device:** Biodex BioStep® Semi-Recumbent Elliptical
  **Mode:** Cardiac
  **Duration:** 5 min. at target heart rate (progress toward 10 min)

- **Gait training:**
  
  **Device:** Biodex Rehabilitation Treadmill
  **Motion:** forward and backward walking
  **Patient Position:** facing control panel
  **Speed:** moderate, increase based on clinical judgment
  **Elevation:** based on clinical judgment
  **Duration:** 20 min each direction
HOME PROGRAM:

- Functional Activities Program: replaces standardized exercises with functional movements that correspond to difficult or strenuous activities

Begin running program when:
- Quadriceps strength deficit is < 35%
- Ham/Quad strength ratio is < 85%
- Laxity parameters are met
- Patient is without pain, swelling/edema, crepitus, or giving way
- Forward: alternate jog/walk at 2:1 ratio, moderate speed (brace on)
- Distance: Base on pre-injury ability
- Backward: walk (brace on)
- Distance: progress toward 0.25 mi. (0.4 km)
- Recommendations: Ice after each bout for 20 min. Avoid rapid deceleration. No cuts or twists off involved leg. Addition of turning, twisting, or jumping to running program must be accompanied by frequent physical examination with laxity evaluation.

- Pain/swelling/edema control:
  - Ice/compression, electrical stim: as directed

- Strengthening:
  - SLR (with resistance as tolerated):
    - Hip EXT/FLEX ABD/ADD: 3 x 30 reps, 3 x /day
    - Hamstring curl: 3 x 10 reps, 3 x/day
    - Heel slide: 3 x 10 reps, 3 x/day
    - Mini-squat: 3 x 10 reps, 3 x/day
    - Single-leg calf raise on step 3 x 40 reps, 3 x/day
    - Stretch calf musculature before and after exercise

- Flexibility (static hold stretch):
  - Sets and Reps: 3 x 15-20 sec hold, 3 x/day
    - Quadriceps
    - Hamstrings
    - Hip flexors
    - Gastrocnemius /Soleus

- Patellar mobilization
  - Superior/inferior and medial/lateral glides 5 min 3x/day

- Cardiovascular training:
  - 65-80% MHR for minimum of 20 min/day 3x/week
REPORTS:

- Analog pain scale
- Cardiovascular fitness level
- Biodex Balance System single leg stance
  Stability Index
- Biodex isokinetic bilateral comparison:
  QUAD/HAM 110°-40° @ 180 deg/sec
  QUAD/HAM full range of motion @ 300 deg/sec
- Tibial AP displacement:
  Involved compared to uninvolved
  Change in involved from previous test
  Total change in involved from first test
- Open Kinetic Chain (OKC) Proprioception:
  Active [muscle mechanoreceptor]
  Passive [joint capsule mechanoreceptor]
PHASE VI

GOALS AND CRITERIA FOR ADVANCEMENT:

- Maintain pain-free ADLs
- ROM 100%
- Laxity: Maintain < 3mm (at 20 lb) variance from uninvolved knee
- Strength:
  - Quadriceps < 10% deficit
  - Hamstrings < 0 % deficit
  - Ham/Quad ratio:
    - > 70% @ 180 deg/sec
    - > 80% @ 300 deg/sec
- Muscle Function: Asymptomatic isokinetic torque curve for QUAD/HAM
- Open Kinetic Chain (OKC) Proprioception:
  - Active < 10% deficit bilaterally
  - Passive < 10% deficit
- Stability Index:
  - Unilateral stance < 10% deficit
  - Bilateral stance within normative value for age
- Functional movement symmetry:
  - (Based on functional hop test comparisons of involved and contralateral uninvolved side)
  - > 85% limb symmetry

CLINICAL EVALUATION:

- Pain scale: location, quality, duration, radiation, and severity
- Hemarthrosis/Effusion: quantify and describe
- Patella: position, mobility and condition
- ROM: AROM and PROM limits
- Verify home program compliance
- TEST: Joint laxity bilaterally
  - Frequency: Every 4th week and last visit this phase
  - Device: Arthrometer, 20 lb (89 N) and 30 lb (134 N)
  - Report: Compare to contralateral normal knee
  - Total change from post-op
  - Change from previous test
**CLINICAL EVALUATION (cont):**

- **TEST: Bilateral isokinetic QUAD/HAM 3 speed evaluation**
  - Frequency: Every 4th week and last visit this phase
  - **Device:** Biodex Multi-Joint System
  - **Motion:** knee EXT/FLEX
  - **Report:** Isokinetic Evaluation – 3 speeds
  - **ROM:** Full
  - **Setup:** 60º/180º/300 deg/sec
  - **Sets and Reps:** 1 x 5 reps for 60 deg/sec
    1 x 10 reps for 180 and 300 deg/sec

- **TEST: Unilateral stability**
  - Frequency: 6th and last visit this phase
  - **Device:** Biodex Balance System
  - **Report:** Stability Index
  - **Stance:** Unilateral (single leg)
  - **Setup:** Dynamic Balance
  - Stability level: 8 (most stable) progressing to 6 (less stable)
  - **Duration:** 5 bouts of 30 sec

- **TEST: OKC Proprioception**
  - Frequency: 6th and last visit this phase
  - **Active (muscle mechanoreceptor)**
  - **Passive (joint capsule mechanoreceptor)**

- **TEST: Functional Movement**
  - **Single leg hops:**
    1. One-legged single hop for distance
    2. One-legged single hop over 20 ft (6 m)
    3. One-legged triple cross-over for distance
  - **Report:** Average % limb symmetry

**CLINICAL TREATMENT OPTIONS:**

- **Strengthening and conditioning:**
  - Increase training demands in terms of effort level, speed, and duration based on individual activity-specific need
  - **Isotonics:** increase resistance to meet demands of specific individual needs
  - **Isokinetics:** Intensify effort and duration to levels based on specific advanced functional needs. Train at velocity spectrum of 180-450 deg/sec
  - High demand activities may require maximal effort isokinetic training. Progressing, for example, up to 5 x 30 reps
  - Close monitoring (at frequent intervals) of all physical parameters is essential

- **Individualized Training**
  - Identify high-demand aspects of individual patient’s activities
  - Initiate specific training to prepare for those demands
  - Decrease intensity of training and/or modify program in presence of any complicating physiological factors

- **Orthosis**
  - Make recommendations for use of brace during activities that have potential to over-stress ACL, especially if indicated by increased tibial laxity.
SUPERVISED PROGRAM:

[Frequencies prescribed on individual basis]

- Strengthening and conditioning:
  - Isotonics: increase resistance to meet demands of specific individual needs
  - Plyometrics: progress based on clinical judgments

- Cardiovascular conditioning: continue building endurance:
  Consider cumulative times of all aerobic programs when setting goals for workouts at or above target heart rate. If, for example, the running program is decreased for physiological reasons, the upper-body cycling program may be intensified.

- Functional Activities Program:
  Proprioception: Integrate high-difficulty movements with running program

HOME PROGRAM:

- Functional Activities Program:
  Replaces standardized exercises with functional movements that correspond to difficult or strenuous activities.

Running (Intermediate Program):
- Begin when able to run short distances and previous running program prerequisites are maintained
- Forward (brace on): gradually increase jog/walk ratio until walking is eliminated
- Distance: progress toward 1 mi. (1.6 km) all jogging - ice after for 20 min
- Backward (brace on): jog, moderate speed
- Distance: progress toward 0.25 mi. (0.4 km) ice after for 20 min

Twisting and cutting (brace on): as directed.
Perform off uninvolved leg. Cut only off involved and only toward opposite side. No jumping.

Recommendations: Avoid rapid deceleration. No cuts or twists off involved leg. Addition of turning, twisting, or jumping to running program must be accompanied by frequent physical examination (with laxity measurement).

Running (Advanced Program):
- Initiate based on specified individual goals
- Prerequisite: must be able to run backward 75 yd (68m)
- NOTE: Increasing functional demands require close monitoring for PF overuse syndromes, pain, inflammation, and increased tibial AP displacement.
- Forward (brace on): 40 yd (36m) sprint, full speed progress toward 20 reps
- Backward (brace on): 20 yd (18m) run, full speed progress toward 20 reps
- Twisting, cutting, jumping (brace on): as directed.
- Perform off uninvolved leg. Avoid straight-leg landing from jumps.

- Pain/swelling/edema control Ice/compression, electrical stim:
  as directed

- Strengthening (hip, knee, and calf musculature):
  - Knee extension: 3 x 10 reps, 3 x/day
  - Hamstring curl: 3 x 10 reps, 3 x/day
  - Mini-squat: 3 x 10 reps, 3 x/day
  - Single-leg calf raise on step: 3 x 40 reps, 3 x/day
  (Stretch calf musculature before exercise)

- Flexibility (static hold stretch):
  Sets and Reps: 3 x 15-20 sec. hold, 3 x/day
  - Quadriceps
  - Hamstrings
  - Hip flexors
  - Gastrocnemius /Soleus
REPORTS:

- All reports to be done bilaterally
- Analog pain scale
- Cardiovascular fitness level
- Biodex Balance System single leg stance
  Stability Index
- Biodex isokinetic bilateral comparison QUAD/HAM @ 60/180/300 deg/sec
  Strength, Power, Endurance, ROM
- Tibial AP displacement:
  Involved compared to uninvolved
  Change in involved from previous test
  Total change in involved from first test
- Open Kinetic Chain (OKC) Proprioception:
  Active [muscle mechanoreceptor]
  Passive [joint capsule mechanoreceptor]
- Functional Movement: Single-leg Hop test
- Impairment Rating
- Activity Recommendations
- Comments
## BIODEX BALANCE SYSTEM

### Stability Index

<table>
<thead>
<tr>
<th>Age (yrs)</th>
<th>Stability Index</th>
<th>Standard Deviation (+/-)</th>
</tr>
</thead>
<tbody>
<tr>
<td>17-35</td>
<td>1.54</td>
<td>.72</td>
</tr>
<tr>
<td>36-53</td>
<td>2.13</td>
<td>.90</td>
</tr>
<tr>
<td>54-71</td>
<td>2.57</td>
<td>.78</td>
</tr>
<tr>
<td>72-89</td>
<td>2.70</td>
<td>.80</td>
</tr>
</tbody>
</table>

Females are more stable than males:

<table>
<thead>
<tr>
<th>All ages</th>
<th>Stability Index</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Females</td>
<td>1.94</td>
<td>.80</td>
</tr>
<tr>
<td>Males</td>
<td>2.70</td>
<td>.08</td>
</tr>
</tbody>
</table>

Values were collected by J.A. Finn, et al, Stability Performance Assessment among Subjects of Disparate Balancing Abilities. Southern Connecticut State University.


### EVIDENCE BASED CLINICAL PROTOCOL FOR THE MANAGEMENT OF:

#### anterior cruciate ligament injury

and reconstruction

<table>
<thead>
<tr>
<th>post Injury:</th>
<th>phase I: Post-Surgical/Reduction of Acute Symptoms</th>
<th>phase II: Range of Motion and Initial Strengthening</th>
</tr>
</thead>
</table>

#### goals:
- Physically prepare patient for surgery
- Quantify physiological baselines
- Reduce Edema
- Regain ROM of involved knee
- Mentally prepare patient for surgery
- Identify special needs
- Identify potential problems
- Protect the graft
- Allow wound healing
- Avoid contractures
- Ambulation with 2 crutches
- Increase patellar mobility
- Reduce pain, effusion and inflammation
- Increase WB as tolerated
- Perform quad set
- Full passive extension
- AROM: 20-70 deg (minimum)
- PROM: 0 > 90 deg
- Joint Laxity: <2mm variance from uninvolved (AP displacement at 20 lbs)

#### clinical evaluations:
- General patient history and observation
- Pain scale: location, quality and duration
- Edema: degree, location and character of swelling
- Patella: position, mobility, condition
- ROM (proven): active and passive
- TEST: Joint laxity bilaterally
- Biodex OKC proprioception test
- Biodex bilateral isokinetic 3 speed QUAD/HAM (60, 180, 300) OR
- Biodex bilateral isometric 3 position QUAD/HAM (30, 60, 90)
- Biodex Balance System Bilateral and Unilateral stance tests
- Verify home program compliance
- Pain scale: location, quality and duration
- Quantify and describe hemarthrosis / edema
- Patella: soft tissue in contracture-prone areas
- Patella: position, mobility and condition
- ROM: AROM and PROM limits
- GL: Quality of contraction
- (Final visit this phase)
- TEST: Joint laxity bilaterally
- BIO: Quadratic/Proprioception test QUAD/HAM @ 60 deg/sec
- BIO: Quadratic/Proprioception test QUAD/HAM @ 60 deg/sec

#### clinical treatment options:
- Rehab process education
- Psychological preparation for rehab
- Reduce edema/manage pain
- PRI.I.C.E.
- Crutch use instruction
- Brace fitting
- Ambulation training
- Instruction on use of crutches
- PROM, AROM and AROM QUAD/HAM
- Strengthening: - Biodex isokinetic QUAD/HAM (180, 300) OR
- Biodex isokinetic closed chain attachment - SLR four planes
- Wall squats with isometric adduction
- Cardiovascular training: BiodeX UBC, LBC or SRC
- Reduce spasm, pain and edema
- ES for pain
- Patellar mobilization
- WB ambulation
- PROM: CPM with BiodeX passive mode
- GIU: Strengthening (atrophy treatment): - Muscle re-education: ES with Quad sets
- PROM
- Treadmill: Vanity mode
- HS Strengthening: Biodex BR System Bilateral
- BiodeX isokinetic passive mode w/ concentric only
- Hip/knee strengthening
- Pain management
- PRI.I.C.E.
- Patella mobilization
- FULL WB ambulation
- ROM: active and active assisted knee and hip ROM
- AROM with BiodeX UBC
- PROM: CPM with BiodeX passive mode
- GIU: Strengthening: - Quad sets with ES for muscle re-education - SBF (planes)
- Biodex Closed Chain attachment terminal extensions
- HS: Strengthening: - Biodex isokinetic multi-angle flexion
- Biodex isokinetic flexion 180/300 deg/sec
- Standing leg curls with ankle weights
- WB Proprioception: Biodex Balance System *F
- Gait: Normalize gait *F
- Cardiovascular training: UBC
- *Note: To be done when WB > 60% # Note: Utilize BiodeX Unweighting System as needed

#### supervised program:
- PRI.I.C.E.
- Reduce edema/manage pain
- Cardiovascular training: BiodeX UBC/LBC
- EMS
- Muscle re-education
- Reduce spasm / pain / edema
- Cardiovascular training: BiodeX UBC
- Muscle re-education
- Quad sets/SLR
- Reduce spasm / pain / edema / swelling
- Cardiovascular training: BiodeX UBC
- Strengthening and flexibility of hip, lower leg and knee
- Pain management
- PRI.I.C.E.
- Patella mobilization
- FULL WB ambulation
- Cardiovascular training: BiodeX UBC
- Strengthening and flexibility of hip, lower leg and knee
- Pain / edema control
- PROM & Patellar mobilization exercises
- Muscle control
- Non-WB strengthening of hip, lower leg and knee
- Flexibility training
- Pain / edema control
- Non-WB strengthening of hip, lower leg and knee
- Flexibility training

#### home program:
- Reduce edema/manage pain
- PROM/AROM
- Patella mobilization exercises
- Practice normal gait
- Strengthening: - SLR four planes
- Quad sets
- Hamstring curls with resistance
- Pain / edema control
- PRI.I.C.E.
- Patellar mobilization
- PROM exercises
- Quad sets/SLR
- NWB muscle control and strengthening
- Pain / edema control
- PROM & Patellar mobilization exercises
- Muscle control
- Non-WB strengthening of hip, lower leg and knee
- Flexibility training

#### reports:
- Biodex isokinetic bilateral comparison
- Biodex isometric bilateral comparison
- Biodex OKC, proprioception test
- Biodex Balance System Bilateral and Unilateral test
- Pain scale
- Level of cardiovascular fitness
- Biodex isokinetic bilateral comparison QUAD/HAM @ 60 deg/sec
- Tibial AP displacement: involved/normal
- Pain scale
- Level of cardiovascular fitness
- Biodex Balance System Bilateral stance
- Biodex isometric bilateral comparison QUAD/HAM @ 60 deg/sec
- Tibial AP displacement: involved/normal
- Initial BiodeX Gait Training evaluation
# EVIDENCE BASED CLINICAL PROTOCOL FOR THE MANAGEMENT OF: anterior cruciate ligament injury and reconstruction

## phase III: Initial Weight-bearing and Intermediate Strengthening

**goals:**
- Protect the graft
- ADLs: pain-free
- Effusion: none
- WB 100%
- Ambulation: unsustained
- Laxity < 2 mm variance from uninvolved
- Stability Index: > 30% deficit of Normative value for age
- AROM: > 125
- AROM: > 135
- Strength:
  - QUA D < 40% deficit
  - HAM < 20% deficit
  - QUA D/HAM ratio > 80%

## phase IV: Progressed Weight-bearing & Strengthening

**goals:**
- Protect the graft
- Maintain pain free ADLs
- Maintain WB
- Maintain full AROM and PROM
- Stability Index: 80% of Normative value for age
- Laxity < 3 mm variance from uninvolved
- Stability Index: Unilateral stance < 20% deficit of Norm.

## phase V: Advanced Strengthening

**goals:**
- Maintain pain free ADLs
- Maintain WB
- Maintain full AROM and PROM
- Pain / edema control
- Effusion: quantify and describe
- Patella: position, mobility and condition
- QUA D: AROM and PROM limits
- ROM: until AROM is pain-free
- WB ambulation without crutch
- Patellar mobilization
- Patella: position, mobility and condition
- Patella: passive range of motion

## phase VI: Return to Activity

**goals:**
- Maintain pain free ADLs
- Maintain WB
- Maintain full AROM and PROM
- Pain / edema control
- Effusion: quantify and describe
- Patella: position, mobility and condition
- ROM: AROM and PROM limits
- Verify home program compliance

## clinical evaluations:

- Verify home program compliance
- Pain scale: location, quality and duration
- Hemarthrosis / Edema: quantify and describe
- Patellar subluxation / dislocation
- Patella: position, mobility and condition
- ROM: AROM and PROM limits
- Quality of QUA D muscle contraction
- TEST: Joint laxity bilaterally
- TEST: Biodex bilateral isometric comparison QUA D/HAM @ 60
- TEST: Biodex bilateral isokinetic comparison QUA D/HAM @ 60
- TEST: Biodex isokinetic QUA D/HAM 110-45 degrees @ 300 deg/sec
- TEST: Biodex Gait Trainer analysis
- TEST: Biodex Balance System Bilateral stance

## clinical treatment options:

- Control pain / edema / inflammation
- Cryo/Cuff
- Patellar mobilization
- AROM: until AROM is pain-free
- WB ambulation without crutch
- QUA D: AROM and PROM limits
- WB mobilization: Biodex Gait Trainer
- WB proprioception: Biodex MJS
- WB proprioception: Biodex Balance System unilateral and bilateral
- Laxity: quantitative and describe
- Patella: position, mobility and condition
- Patellar mobilization
- Patella: passive range of motion
- Patella: position, mobility and condition
- Patella: passive range of motion

## supervised program:

- Manage pain / edema
- Cardiovascular training: Biodex LBC/LBC
- Strengthening of hip, knee and ankle musculature
- Pain / edema control
- WB and Non-WB Strengthening: Hip and ankle musculature
- Gain Training

## home program:

- Manage pain / edema
- Cardiovascular training: LBC/LBC
- WB and Non-WB Strengthening: Hip and ankle musculature
- Gain Training
- Pain / edema control
- WB strengthened: Hip, knee and ankle
- Flexibility training
- Cardiovascular training
- Functional activity program
- Pain / edema control
- WB strengthening: Hip, knee and ankle
- Flexibility training
- Cardiovascular training

## reports:

- Level of cardiovascular fitness
- Biodex isokinetic bilateral comparison QUA D/HAM @ 60
- Biodex isokinetic comparison QUA D/HAM @ 60
- Biodex Gait Trainer analysis
- Biodex Balance System unilateral and bilateral stance
- Tibial AP displacement
- Pain scale
- Level of cardiovascular fitness
- Biodex isokinetic bilateral comparison QUA D/HAM @ 60
- Biodex isokinetic bilateral comparison QUA D/HAM @ 60
- Biodex Gait Trainer analysis
- Biodex Balance System unilateral and bilateral stance
- Biodex OKC Proprioception
- Tibial AP displacement
- Pain scale
- Level of cardiovascular fitness
- Biodex isokinetic bilateral comparison QUA D/HAM @ 60
- Biodex isokinetic bilateral comparison QUA D/HAM @ 60
- Biodex Gait Trainer analysis
- Biodex Balance System unilateral and bilateral stance
- Biodex OKC Proprioception
- Tibial AP displacement