# ADVANCED MENISCUS REPAIR: RADIAL, ROOT, HORIZONTAL CLEAVAGE TEAR CLINICAL PRACTICE GUIDELINE

## Disclaimer

The following rehabilitation guidelines are specific to patients who have undergone an advanced meniscus repair of a radial, root or horizontal cleavage tear. Please refer to the Ohio States Sports Medicine website for rehabilitation guidelines specific to other procedures and conditions, as appropriate.

Progression is criterion-based and dependent on soft tissue healing, patient demographics, and clinical evaluation. The time frames identified for each phase of rehabilitation are approximate times for the average patient and not recommended as guidelines for progression for the individual patient. It is recommended that progression is based upon the achievement of functional criteria demonstrating readiness for progression, noted at the end of each phase.

## Background

Meniscal root/radial tears present in a variety of forms, ranging from partial to complete avulsion. Root and radial tears can have a profound effect on the health of the articular cartilage of the knee with the potential for meniscal extrusion and accelerated arthritic degeneration if left untreated. Horizontal cleavage tears can result in advanced degeneration of the meniscus tissue and underlying cartilage, especially during high-impact activity. The listed clinical recommendations are a result of the complexity of the surgical technique.

The rehabilitation recommendations below are based upon the guidance of content experts, surgeons, and evidence-based practice. Progression through each phase, after precautions have been lifted, is based on the patient demonstrating readiness by achieving the listed functional criteria.

## Summary of Recommendations

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| **Precautions** | • WBing and bracing recommendations are based on tear morphology and intra-operative findings. Recommendations are below. **However, ALWAYS refer to the operative note or contact the surgical team for clarification.**<br>• For root/radial tears – no resisted isotonic hamstring strengthening x8 weeks<br>• Many of these patients will be encouraged to wear a medial unloader brace for the first 12 months post-op |
| **Risk Factors** | The patient should be monitored for signs and symptoms of DVT (see Red/Yellow Flag section) |
| **Weight Bearing/Bracing** | **Root Repair:**<br>• TROM immobilizer for first 10-14 days post-op<br>• NWBing x 4 weeks, with a goal of crutch discharge by 6 weeks<br><br>**Radial Repair:**<br>• Typically NWBing x 4 weeks, with a goal of crutch discharge by 6 weeks<br>• WBing status and bracing are patient dependent – always refer to the operative note or contact the surgical team for clarification<br><br>**Horizontal Cleavage Repair:**<br>• No brace<br>• NWBing x 2-4 weeks, crutches should be discharged no later than 6 weeks<br><br>***Please refer to the "post-op plan" section of the operative note or contact the surgeon for clarification*** |
| **Range of Motion** | • Week 0-2: 0-90°<br>• Week 2-4: progress to full PROM<br>• Week 4+: full AROM<br>*Symmetrical knee extension should be achieved by week 4. If not achieved by week 4, contact surgeon* |
| **Outcome Tools** | Collect the LEFS at each visit<br><br>*You may choose to include IKDC, KOOS, ACL-RSI, Tegner or other questionnaires specific to your patient's needs* |
| **Hamstring Considerations** | Root/Radial Repairs: No resisted isotonic hamstring strengthening x8 weeks<br><br>*No hamstring precautions for horizontal cleavage repairs* |
| **Functional Testing** | • **Isometric Testing**<br>  ○ Root/Radial Repairs: 4 months<br>  ○ Horizontal Cleavage Repairs: 3 months<br>• **Isokinetic Testing**<br>  ○ Root/Radial Repairs: 6 months<br>  ○ Horizontal Cleavage Repairs: 4 months<br>• **Hop testing:** *should not be performed prior to 6 months post-op and is only appropriate after 80% symmetry is achieved on isokinetic testing*<br>  ○ SL hop for distance<br>  ○ Triple hop<br>  ○ Cross over hop<br>  ○ Timed 6m hop<br>**Functional strength testing and hop testing should be reserved for patients returning to high level activity** |

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| **Criteria to Discharge Assistive Device** | • **ROM**: Full active knee extension; no pain on passive overpressure<br>• **Strength**: Able to perform strong quad isometric with full tetany and superior patellar glide and able to perform 2x10 SLR without quad lag<br>• **Effusion**: 1+ or less is preferred (2+ acceptable if all other criteria are met)<br>• **Weight Bearing:** Demonstrates pain-free ambulation without visible gait deviation |
| **Criteria to D/C NMES** | • <20% quad deficit on isometric testing<br>• If Biodex not available:<br>  ○ 10 SLR without quad lag<br>  ○ Normal gait<br>  ○ 10 heel taps to 60° knee flexion with good quality<br>  ○ 10 rep max on leg press and similar effort bilaterally<br>  ○ Inability to break quad MMT (5/5) |
| **Criteria to Initiate Running and Jumping** | • **ROM**: full, pain-free knee ROM, symmetrical with the uninvolved limb<br>• **Strength**: Isokinetic testing 80% or greater for hamstring and quad at 60º/sec and 300º/sec<br>• **Effusion**: 1+ or less<br>• **Weight Bearing:** normalized gait and jogging mechanics<br>• **Neuromuscular Control:** Pain-free hopping in place |
| **Criteria to Return to Sports Participation** | • **ROM**: full, pain-free knee ROM, symmetrical with the uninvolved limb<br>• **Strength**: Isokinetic testing 90% or greater for hamstring and quad at 60º/sec and 300º/sec<br>• **Effusion**: No reactive effusion ≥ 1+ with sport-specific activity<br>• **Weight Bearing**: normalized gait and jogging mechanics<br>• **Neuromuscular control:** appropriate mechanics and force attenuation strategies with high level agility, plyometrics, and high impact movements<br>• **Functional Hop Testing:** LSI 90% or greater for all tests<br>• **Physician Clearance** |
| **Return to Sport Expectation** | 6-12 months depending on type of repair, patient's goals and sports-specific demands |

## RED/YELLOW FLAGS

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| **Red Flags**<br><br>*Require immediate referral for re-evaluation* | • Signs of DVT→ *Refer directly to ED*<br>  ○ Localized tenderness along the distribution of deep venous system<br>  ○ Entire LE swelling<br>  ○ Calf swelling >3cm compared to asymptomatic limb<br>  ○ Pitting edema<br>  ○ Collateral superficial veins<br>• Lack of full knee extension by 4 weeks post-op →*Refer to surgeon for re-evaluation*<br>• Mechanical block or clunk →*Refer to surgeon for re-evaluation*<br>• Reported episodes of instability →*Refer to surgeon for re-evaluation* |
| **Yellow Flags**<br><br>*Require modifications to plan of care* | • Persistent reactive effusion or pain following therapy or ADLs<br>  ○ *Decrease intensity of rehab interventions, continue effusion management, educate patient regarding activity modifications until symptoms resolve* |

## Phase I: Protection (Post-Operative—6 weeks)

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| **Goals** | Protect repair, restore ROM, minimize effusion and pain while adhering to all post-operative precautions |
| **Pain and Effusion** | Effusion management strategies: cryotherapy and compression as appropriate |
| **ROM** | **Week 0-2:** 0-90°<br>**Week 2-4:** progress to full PROM<br>**Week 4+:** full AROM<br><br>*Symmetrical knee extension should be achieved by week 4. If not achieved by week 4, contact surgeon.*<br><br>Extension ROM: Seated towel stretch, bag hang *(Appendix A)*<br>Flexion ROM: Use PROM/AAROM techniques for first 4 weeks<br>○ Heel slides, wall slides, upright cycling (starting week 2 for ROM only, ½ revolutions → full revolutions) |
| **Weight Bearing** | **Root Repair:**<br>• TROM immobilizer for first 10-14 days post-op<br>• NWBing x 4 weeks, with a goal of crutch discharge by 6 weeks<br><br>**Radial Repair:**<br>• Typically NWBing x 4 weeks, with a goal of crutch discharge by 6 weeks<br>• WBing status and bracing are patient dependent – always refer to the operative note or contact the surgical team for clarification<br><br>**Horizontal Cleavage Repair:**<br>• No brace<br>• NWBing x 2-4 weeks, crutches should be discharged no later than 6 weeks<br><br>***Please refer to the "post-op plan" section of the operative note or contact the surgeon for clarification*** |
| **Open Chain Knee Extension Progression** | Open Kinetic Chain Extension:<br>• Unresisted partial range LAQ - Weeks 1-2<br>• Multi-angle isometrics at 90° and 60° - Weeks 1-2<br>• Unresisted full range LAQ - Weeks 2-3<br>• Multi-angle isometrics at 90°, 60° and 30° - Weeks 2-3<br>• Knee extension machine (partial range → full range) – Weeks 4+ |
| **Suggested Interventions** | *For root/radial tears – no resisted isotonic hamstring strengthening x8 weeks*<br>• Ankle pumps<br>• Quadriceps, hamstring and gluteal isometrics<br>• Diaphragmatic breathing<br>• Effusion management strategies (RICE)<br>• Strong emphasis on patellar mobilizations – all directions<br>• Prone TKE<br>• SLR-4 way<br>○ Consider progression with progressing to seated, eyes closed, holds, pulses, ABCs<br>• Gait training (as appropriate per WBing status and post-op precautions)<br>• SAQ (unweighted)<br>• OKC progression (see above)<br>• Clamshell |

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| | • NMES<br>• Once NWBing precaution is lifted: (patient dependent – refer to op-note or surgical team)<br>  ○ Standing TKE (perform through phases of gait)<br>  ○ SL stance (eyes open → eyes closed) |
| **Blood Flow Restriction Training** *Appendix D* | • Blood Flow Restriction (BFR) training can be initiated as soon as sutures are removed<br>• Ensure patient has no contraindications (Appendix D) and if patient has any listed precautions or are at risk for a DVT, clear with physician before initiating BFR<br>• Use BFR twice weekly for up to 10 weeks; use for 2-3 exercises per session<br>• Can be used with any exercise that is safe for patient to perform depending on time since surgery (ex. SLR 4-way, prone TKE). *BFR should never be performed during a plyometric exercise.*<br>• Training Load: 20-40% 1 RM (Estimated, or use OMNI-RES, see Appendix D)<br>• Limb Occlusion Pressure= 80% (see Appendix D if patient unable to tolerate)<br>• 4 sets for each exercise with reps of 30-15-15-15 (75 total) with a 30 second rest break between sets, keeping cuff inflated the entire duration of each exercise. Deflate between exercises, or every 8 minutes. |
| **NMES Parameters** *Appendix B* | • NMES pads are placed on the proximal and distal quadriceps<br>• Patient: Seated with the knee in at least 60º flexion, shank secured with strap and back support with thigh strap preferred. The ankle pad/belt should be two finger widths superior to the lateral malleoli<br>• The patient is instructed to relax while the e-stim generates at least 50% of their max volitional quadriceps contraction OR maximal tolerable amperage without knee joint pain<br>20 seconds on/ 50 seconds off x 15 min |
| **Criteria to Discharge Assistive Device** | • **ROM**: Full active knee extension; no pain on passive overpressure<br>• **Strength**: Able to perform strong quad isometric with full tetany and superior patellar glide and able to perform 2x10 SLR without quad lag<br>• **Effusion**: 1+ or less is preferred (2+ acceptable if all other criteria are met) (*Appendix C)*<br>• **Weight Bearing:** Demonstrates pain-free ambulation without visible gait deviation |
| **Criteria to Progress to Early Loading Phase** | • Pain-free knee flexion of >120 degrees<br>• Pain-free and full passive knee extension<br>• Proficient heel-to-toe gait without assistive device<br>• Reduced and well-controlled post-operative pain and edema<br>• Ability to perform a strong isometric quadriceps contraction (full tetany and superior patellar glide) and SLR without evidence of quad lag<br>• Proficiency with home-exercise program |

## Phase II: Early Loading (7-9 Weeks)

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| **Goals** | Emphasis is placed on normalizing ROM, improving quadriceps/gluteal/core strength and safe progression towards functional loading |
| **Pain and Effusion** | Cryotherapy/compression as needed for reactive effusion |
| **ROM** | Full and pain-free ROM<br><br>*Symmetrical knee extension should be achieved by week 4. If not achieved by week 4, contact surgeon* |
| **Weight Bearing** | FWBing with normalized gait pattern |
| **Suggested Interventions** | *For root/radial tears – no resisted isotonic hamstring strengthening x8 weeks*<br>*Maintain CKC flexion <70° for all repair types*<br><br>• Continue Phase I interventions and effusion management strategies<br>• OKC progress as outlines above<br>• Bridges<br>• Side steps/monster walks<br>• Progress SLS (compliant surfaces, dynamic movements)<br>• Add lumbopelvic stability training (TrA progression, prone/side planks, ect)<br>• Partial BW Shuttle Press ( DL→SL)<br>• Closed Chain exercises: mini-squats, wall sits, heel raises<br>• Initiate resisted hamstring strengthening at 8+ weeks for root/radial tears<br>  • OKC hamstring strengthening (DL → SL)<br>  • SB HS curl progression<br>• BFR (continue as in early phase, adding appropriate exercises)<br>• Continue NMES |
| **Criteria to Progress to Strengthening and Return to Function Phase** | • ROM: full and pain-free AROM and normalized patellofemoral mobility<br>• Effusion: <1+<br>• Strength: Quadriceps set with normal superior patellar translation, SLR x10” without extensor lag<br>• Weightbearing: normalized gait, able to tolerate CKC therex program without increased pain or effusion |

## Phase III: Strengthening/Return to Function (10-15 Weeks)

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| **Goals** | • Progress functional balance/NM control<br>• Progress LE strengthening<br>• Progress core stability |
| **Pain and Effusion** | Monitor reactive effusion as progressive loading is performed |
| **ROM** | Full ROM with no complaints of pain with end-range overpressure |
| **Weight Bearing** | FWB with normalized gait pattern |
| **Suggested Interventions** | *Maintain CKC flexion <70° for all repair types*<br><br>• Continue Phase I/II interventions and effusion management as appropriate<br>• OKC progression as outlined above<br>• Continue to progress balance and proprioception interventions per patient's tolerance<br>• BOSU squats (DL → SL)<br>• Heel Taps: starting at 2" step and progressing per patient's tolerance/ability<br>• Step Ups: starting at 4-6" step and progressing per patient's tolerance/ability<br>• Stationary lunges → walking lunges<br>• SL sit to stand, through protected ROM<br>• Core strengthening<br>• Conditioning (permitted at 12+ weeks)<br>  ○ Elliptical<br>  ○ Treadmill walking<br>  ○ Freestyle swimming (no fins until week 16)<br>• BFR (continue as in early phase, adding appropriate exercises)<br>• Continue NMES until 80% symmetry is obtained (see criteria to discharge below) |
| **Strength Testing** | • Isometric testing:<br>  ○ Root/Radial Repairs: 16 weeks<br>  ○ Horizontal Cleavage Repairs: 12 weeks |
| **Criteria to Discharge NMES** | • <20% quad deficit on isometric testing<br>**OR if Biodex machine is not available:**<br>• 10 SLR without quad lag<br>• Normal gait<br>• 10 heel taps to 60 deg knee flexion with good quality<br>• 10 rep max on Leg Press and similar effort bilaterally<br>• Inability to break quad MMT |
| **Criteria to Progress to Return to Activity Phase** | • ROM: maintain full, pain free AROM<br>• Effusion: <1+<br>• Strength: 80% LSI (isometric testing or alternative measure – see *Appendix D*)<br>• Weight Bearing: able to tolerate therapeutic exercise program without increased pain or >1+ effusion<br>• NM control: demonstrates proper lower extremity mechanics with all therapeutic exercises |

## Phase IV: Return to Activity (4 – 6 months)

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| **Goals** | Patients should continue skilled physical therapy to progress functional strengthening. Strength testing is performed to determine readiness to initiate Phase V (RTS). |
| **Pain and Effusion** | Monitor reactive effusion as progressive loading performed |
| **ROM** | Full ROM with no complaints of pain with end-range overpressure |
| **Weight Bearing** | FWB with normalized gait pattern |
| **Strength Testing**<br>*Appendix E, F, G* | • **Isometric Testing**<br>  ○ Root/Radial Repairs: 4 months<br>  ○ Horizontal Cleavage Repairs: 3 months<br>• **Isokinetic Testing**<br>  ○ Root/Radial Repairs: 6 months<br>  ○ Horizontal Cleavage Repairs: 4 months<br>• **Hop testing:** *should not be performed prior to 6 months post-op and is only appropriate after 80% symmetry is achieved on isokinetic testing*<br>  ○ SL hop for distance<br>  ○ Triple hop<br>  ○ Cross over hop<br>  ○ Timed 6m hop<br>**Functional strength testing and hop testing should be reserved for patients returning to high level activity** |
| **Suggested Interventions** | *Maximum CKC flexion: 90° for all repair types*<br>Performance of the quadriceps, hamstrings and trunk dynamic stability<br>• OKC progression, SL squats, SL sit to stand, progress resistance on leg extension/leg curl/leg press machine, RDLs, lunges (multi-direction), crunches, rotational trunk exercises on static and dynamic surfaces, monster walks<br>• Single-leg squats on BOSU with manual perturbation to trunk or legs, Single-leg BOSU balance with perturbation/dynamic movement, single-leg BOSU Romanian deadlift<br><br>Once strength criteria have been met, perform the following progression:<br>• PBW jumping on the shuttle (DL → SL)<br>• Full body weight jumping progression<br>• Walk-jog program |
| **Criteria to Initiate Running and Jumping** | 4+ months for HCT, 6+ months for Root/Radial<br>• **ROM**: full, pain-free knee ROM, symmetrical with the uninvolved limb<br>• **Strength**: Isokinetic testing 80% or greater for hamstring and quad at 60º/sec and 300º/sec<br>• **Effusion**: 1+ or less<br>• **Weight Bearing:** normalized gait and jogging mechanics<br>• **Neuromuscular Control:** Pain-free hopping in place |
| **Criteria to Progress to Return to Sport Phase** | • Quadriceps and hamstring symmetry of 80% or greater<br>• Ability to tolerate walking distances of 3 miles or greater without reactive pain or effusion<br>• Ability to effectively negotiate uneven ground, including soft sand, without reactive pain or effusion<br>• Ability to return to pre-operative low-impact recreational activities, including cycling, elliptical and weight training |

## Phase V: Return to Sport (6 months - RTS)

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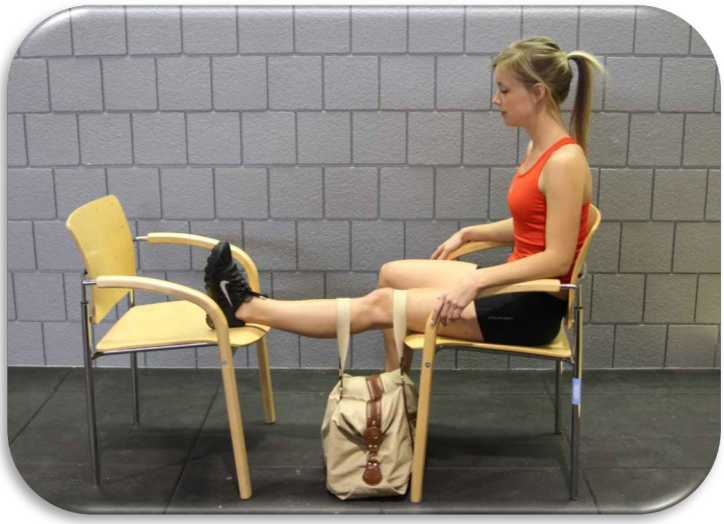
| **Goals** | The patient is able to resume all normal functionality and will continue to progress towards return to sport |
| **Pain and Effusion** | Monitor reactive effusion as progressive loading performed |
| **ROM** | Full ROM with no complaints of pain during end-range overpressure |
| **Weight Bearing** | FWB with normalized gait pattern |
| **Strength Testing**<br>*Appendix E, F, G* | • **Isometric Testing**<br>  ○ Root/Radial Repairs: 4 months<br>  ○ Horizontal Cleavage Repairs: 3 months<br>• **Isokinetic Testing**<br>  ○ Root/Radial Repairs: 6 months<br>  ○ Horizontal Cleavage Repairs: 4 months<br>• **Hop testing:** *should not be performed prior to 6 months post-op and is only appropriate after 80% symmetry is achieved on isokinetic testing*<br>  ○ SL hop for distance<br>  ○ Triple hop<br>  ○ Cross over hop<br>  ○ Timed 6m hop<br>**Functional strength testing and hop testing should be reserved for patients returning to high level activity** |
| **Suggested Interventions** | *No deep squatting (>90°) for 6+ months*<br>Continue progressive strength training per previous phases<br><u>Agility</u><br>• Begin agility exercises between 50-75% effort (utilize visual feedback to improve mechanics as needed)<br>• Advance plyometrics: Bilateral to single leg, progress by altering surfaces, adding ball toss, 3D rotations, etc.<br>• Side shuffling, Carioca, Figure 8, Zig-zags, Resisted jogging (Sports Cord) in straight planes, backpedaling<br><br><u>Plyometrics</u><br>• Single-leg hop downs from increasing height (up to 12” box), Single-leg hop-holds, Double and single-leg hopping onto unstable surface, Double and single-leg jump turns, Repeated tuck jumps<br><u>Sport and position specific training</u> |
| **Criteria for Return to Sport** | • **ROM**: full, pain free knee ROM, symmetrical with the uninvolved limb<br>• **Strength**: Isokinetic testing 90% or greater for hamstring and quad at 60º/sec and 300º/sec<br>• **Effusion**: No reactive effusion ≥ 1+ with sport-specific activity<br>• **Weight Bearing:** normalized gait and jogging mechanics<br>• **Neuromuscular Control:** appropriate mechanics and force attenuation strategies with high level agility, plyometrics, and high impact movements<br>• **Functional Hop Testing:** LSI 90% or greater for all tests<br>• **Physician Clearance** |

## Appendix A: Bag Hang

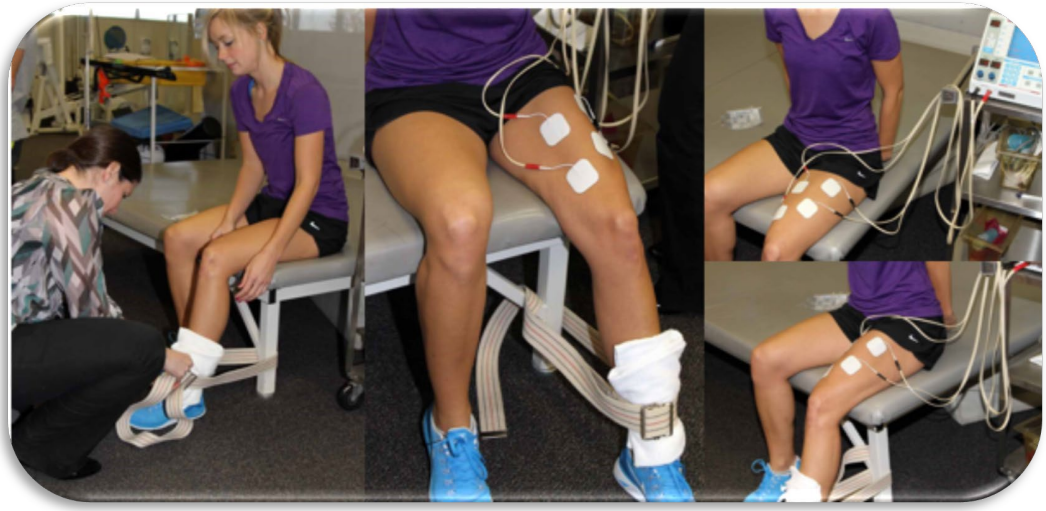
*Emphasis on low load, long duration stretching.*

Goal: 60 minutes TOTAL per day (4x15 minutes, 2x30minutes, etc)



## Appendix B: NMES Set Up

*2 or 4 pad set-up is appropriate*



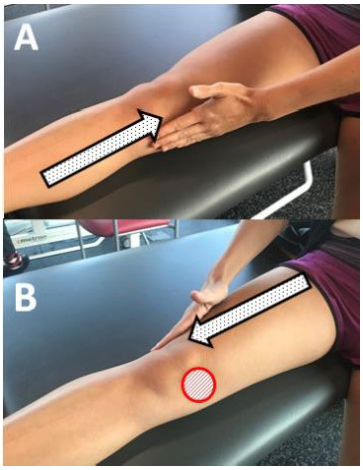
## Appendix C: Stoke Test / Swelling Assessment

### The Stroke Test

The stroke test is a great way to assess your swelling independently. The results of this assessment will help you decide what exercises are appropriate.

A. Using one hand, gently sweep the inside portion of your knee 2-3 times (pushing toward the hip joint).

B. On the outside portion of the knee, immediately sweep downward (toward the ankle). Watch the inside portion of the knee *(indicated by hashed circle in photo)* for a wave of fluid to appear during the downstroke.




### Grading System

*(Table adapted from Sturgill L et al, Journal of Orthopaedic & Sports Physical Therapy, 2009)*

| Test Result | Grade |
|---|---|
| No wave produced on downstroke | Zero |
| Small wave on inside aspect of knee with downstroke | Trace |
| Large bulge on inside aspect of knee with downstroke | 1+ |
| Swelling spontaneously returns to inside aspect of knee after upstroke (no downstroke necessary) | 2+ |
| So much fluid that it is not possible to move the swelling out of the inside aspect of the knee | 3+ |

### Indications for Activity

| 3+ or 2+ | 1+ | Trace or Zero |
|---|---|---|
| **Red Light** | **Yellow Light** | **Green Light** |
| • No running, jumping or cutting or heavy lifting until swelling decreases to 1+ or less<br>• Do not progress program until you speak with your therapist<br>• Utilize swelling management strategies (ice, compression, elevation, NSAIDs) | • Proceed with caution<br>• You may participate in running, jumping and normal lifting routine.<br>• Check effusion before and after workouts<br>• Utilize swelling management strategies (ice, compression, elevation, NSAIDs) | • May participate in running, jumping and normal lifting routine without restriction<br>• Continue to monitor swelling after activity |

# Appendix D: Blood Flow Restriction Training

| Precautions (must get permission from MD) | Contraindications |
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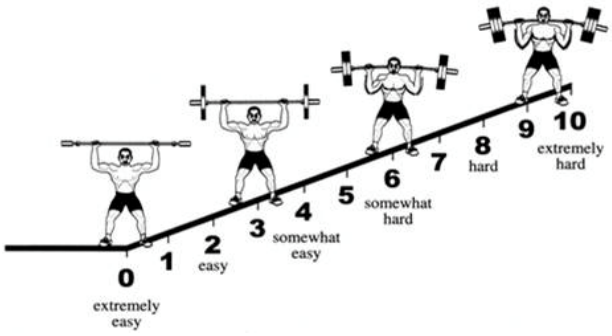
| ▪ Patients with poor circulatory systems (Indicators: shining or scaly skin, brittle dry nails, extremity hair loss, increased capillary filling time, and presence of varicose veins)<br>▪ Patients who are obese or with limb tissue that is loose<br>▪ Arterial claudification<br>▪ Abnormal clotting times<br>▪ Diabetes<br>▪ Sickle cell trait<br>▪ Tumor<br>▪ General infection<br>▪ Hypertension<br>▪ Cardiopulmonary conditions<br>▪ Renal compromise<br>▪ Clinically significant acid-base imbalance<br>▪ Atherosclerotic vessels<br>▪ Taking anti-hypertensive medications | ▪ Venous thromboembolism<br>▪ Impaired circulation or peripheral vascular compromise<br>▪ Previous revascularization of the extremity<br>▪ Extremities with dialysis access<br>▪ Acidosis<br>▪ Sickle cell anemia<br>▪ Extremity infection<br>▪ Tumor distal to the tourniquet<br>▪ Medications/supplements known to ↑ clotting risk<br>▪ Open fracture<br>▪ Increased intracranial pressure<br>▪ Open soft tissue injuries<br>▪ Post-traumatic hand reconstructions<br>▪ Severe crushing injuries<br>▪ Severe hypertension<br>▪ Elbow surgery with excessive swelling<br>▪ Skin grafts in which all bleeding points distinguished<br>▪ Secondary or delayed procedures after immobilization<br>▪ Vascular grafting lymphectomies<br>▪ Cancer |

Training Intensity: 20-40% 1RM or use the Omnibus Resistance Exercise Scale (below). Patient chooses weight/resistance that corresponds to 2-3



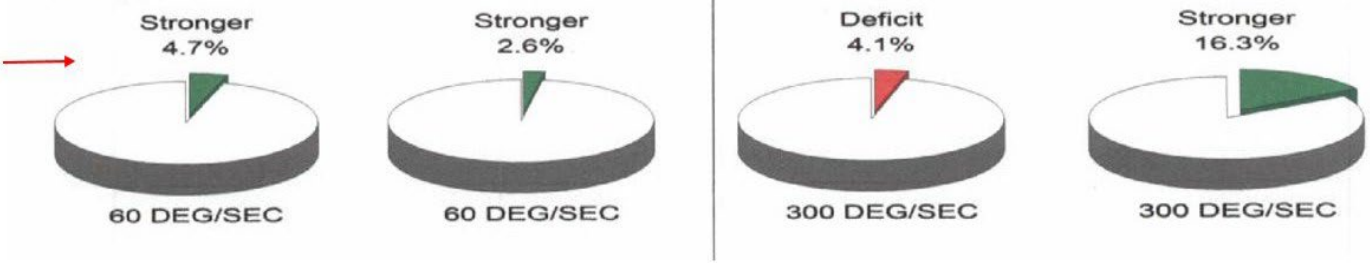

Exercise Prescription:

- If Patient achieves:
  - 75 repetitions: continue with training, re-assess intensity within 1-3 sessions and change as strength improves
  - 60-74 repetitions: continue with training, but extend rest period between sets 3 and 4 to 45 seconds until 75 repetitions is completed
  - 45-59 repetitions: continue with training, but extend rest period between all sets to 45-60 seconds
  - <44 repetitions: reduce load by approximately 10% until repetitions are achieved
- If patient is forced to stop before 75 repetitions due to undue pain, soreness, or general uncomfortable feeling underneath the cuff→ reduce tourniquet pressure by 10mmHg at each training session until cuff tolerance is achieved. Ramp cuff pressure back up by 10 mmHg to target limb occlusion pressure if patient can tolerate.

## Appendix E: Isokinetic Data Interpretation

| | | EXTENSION 60 DEG/SEC | | | FLEXION 60 DEG/SEC | | | EXTENSION 300 DEG/SEC | | | FLEXION 300 DEG/SEC | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| # OF REPS (60/60): 5 | | UNINVOL | INVOLVED | DEFICIT | UNINVOL | INVOLVED | DEFICIT | UNINVOL | INVOLVED | DEFICIT | UNINVOL | INVOLVED | DEFICIT |
| # OF REPS (300/300): 10 | | RIGHT | LEFT | | RIGHT | LEFT | | RIGHT | LEFT | | RIGHT | LEFT | |
| A → PEAK TORQUE | FT-LBS | 127.6 | 133.6 | -4.7 | 53.1 | 54.5 | -2.6 | 69.5 | 66.7 | 4.1 | 39.8 | 46.3 | -16.3 |
| PEAK TQ/BW | % | 111.0 | 116.2 | | 46.2 | 47.4 | | 60.5 | 58.0 | | 34.6 | 40.3 | |
| MAX REP TOT WORK | FT-LBS | 138.4 | 141.7 | -2.4 | 71.8 | 60.3 | 16.0 | 75.7 | 80.6 | -6.5 | 37.1 | 29.6 | 20.0 |
| B → COEFF. OF VAR. | % | 2.8 | 2.1 | | 3.4 | 8.4 | | 8.5 | 7.0 | | 9.1 | 10.4 | |
| AVG. POWER | WATTS | 116.9 | 131.1 | -12.2 | 59.5 | 52.8 | 11.3 | 211.9 | 232.4 | -9.7 | 96.1 | 86.2 | 10.3 |
| C → TOTAL WORK | FT-LBS | 655.8 | 643.7 | 1.8 | 341.9 | 256.2 | 25.1 | 661.0 | 699.2 | -5.8 | 322.6 | 274.1 | 15.0 |
| ACCELERATION TIME | MSEC | 50.0 | 30.0 | | 40.0 | 40.0 | | 60.0 | 60.0 | | 110.0 | 100.0 | |
| DECELERATION TIME | MSEC | 50.0 | 50.0 | | 40.0 | 30.0 | | 90.0 | 80.0 | | 90.0 | 80.0 | |
| ROM | DEG | 95.6 | 89.8 | | 95.6 | 89.8 | | 95.8 | 95.6 | | 95.8 | 95.6 | |
| AVG PEAK TQ | FT-LBS | 124.7 | 130.8 | | 51.0 | 49.1 | | 60.7 | 61.9 | | 30.3 | 39.7 | |
| D → AGON/ANTAG RATIO | % | 41.6 | 40.8 | G: N/A | | | | 57.2 | 69.4 | G: N/A | | | |

E →




| | | Definition | Clinical Impact | What to do |
|---|---|---|---|---|
| A | Peak Torque (ft-lbs) | Peak torque during repetitions | Symmetry criteria (see 'E'- this is the data represented in pie charts) | If <80%; continue unilateral, high resistance strength training |
| B | Coefficient of Variance (%) | Between repetition variability | Goal: < 15% | If >15%, consider retest |
| C | Total Work (ft-lbs) | Torque over all repetitions | Possible indicator of fatigue | If >10%; consider high volume training |
| D | Agonist/Antagonist Ratio (%) | Hamstring/Quadriceps Ratio | Goal: >60% | <60%; ensure 1:1 quadriceps:hamstring exercise ratio |
| E | Limb Symmetry Pie Charts | Strength relative to involved limb | Goal: <10% asymmetry (either direction- deficit OR stronger on involved limb) | If <80%, continue NMES in addition to strength training<br>If <90%, continue unilateral > bilateral strength training emphasis |

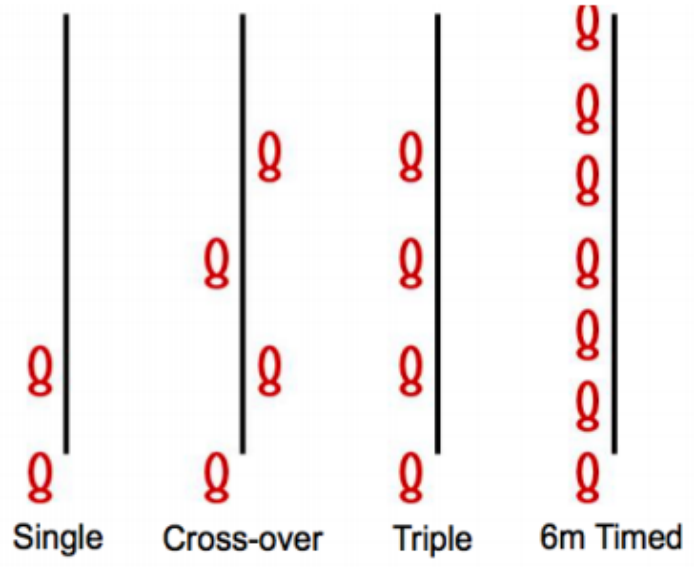
## Appendix F: Isokinetic Testing and Appropriate Alternatives

Sinacore, J. A., Evans, A. M., Lynch, B. N., Joreitz, R. E., Irrgang, J. J., & Lynch, A. D. (2017). Diagnostic accuracy of handheld dynamometry and 1-repetition-maximum tests for identifying meaningful quadriceps strength asymmetries. *Journal of orthopaedic & sports physical therapy*, *47*(2), 97-107.

| | | |
|---|---|---|
| **Isokinetic Dynamometry** |  | • Considered the "gold standard"<br>• 60°/sec for strength and power assessment<br>• 300°/second for speed and endurance assessment |
| **Hand Held Dynamometry with Static Fixation at 90°** |  | • Appropriate alternative<br>• Results may overestimate quadriceps strength symmetry: be cautious with data interpretation |
| **SL 1RM Knee Extension Machine: 90°- 45°** |  | • Appropriate alternative<br>• Recommended to decrease stress on PF joint and limit strain on reconstructed ACL for up to 6 months<br>• Results may overestimate quadriceps strength symmetry: be cautious with data interpretation |
| **SL 1RM Leg Press** |  | • Fair alternative<br>• Results in significant overestimation of quadriceps strength symmetry due to compensation from other LE muscle groups |
| **SL 1RM Knee Extension Machine: 90°- 0°** |  | • Fair alternative<br>• May be uncomfortable and/or inappropriate due to PF stress |

## Appendix G: Single Leg Hop Series

1) **Single hop for distance:** Have the subject line their heel up with the zero mark of the tape measure, wearing athletic shoes. The subject then hops as far as he/she can, landing on the same push off leg, for at least 3 seconds. The arms are allowed to move freely during the testing. Allow him/her to perform 2 practice hops on each leg. Then, have the subject perform 2 testing trial, recording each distance from the starting point to the back of the heel. Average the distanced hopped for each limb. The Limb Symmetry Index: Involved limb distance/Uninvolved limb distance X 100%.
2) **Cross-over hop for distance:** The subject lines their heel up with the zero mark of the tape measure and hops 3 times on one foot, crossing fully over the center line each time. Each subject should hop as far forward as he/she can on each hop, but only the total distance hopped is recorded. The arms are allowed to move freely during the testing. Allow him/her to perform 2 practice hops on each leg. Then, have the subject perform 2 testing trial, recording each distance from the starting point to the back of the heel. Average the distanced hopped for each limb. The Limb Symmetry Index: Involved limb distance/Uninvolved limb distance X 100%.
3) **Triple hop for distance:** The subject lines their heel up with the zero mark of the tape measure and hops 3 times on one foot. Each subject should hop as far forward as he/she can on each hop, but only the total distance hopped is recorded. The arms are allowed to move freely during the testing. Allow him/her to perform 2 practice hops on each leg. Then, have the subject perform 2 testing trial, recording each distance from the starting point to the back of the heel. Average the distanced hopped for each limb. The Limb Symmetry Index: Involved limb distance/Uninvolved limb distance X 100%.
4) **Timed 6-meter hop:** The subject lines their heel up at the zero mark of the tape measure and hops, on cue with the tester, as fast as they can the length of the 6-meter tape. The arms are allowed to move freely during the testing. Allow him/her to perform 2 practice hops on each leg. Then, have the subject perform 2 testing trial, recording each distance from the starting point to the back of the heel. Average the distanced hopped for each limb. The Limb Symmetry Index: Involved limb time/Uninvolved limb time X 100%.



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