

Case Report

Physical therapy to improve mobility following surgery for multiple ligament knee injuries: A case report

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Abstract

Background and purpose: The purpose of this case report is to provide a student physical therapist's prospective in managing a patient with multiple knee ligament injuries and the clinical decision making process used to choose the most effective physical therapy interventions to restore knee mobility following surgical reconstruction.

Case description: The patient is a 21-year-old male nine weeks status post elective anterior cruciate ligament autograft Bone-Tendon-Bone reconstruction, medial/lateral meniscal repair and debridement of synovitis multiple compartments and sprain to the posterior cruciate ligament. His chief complaints post-operatively were pain in right knee, limited range of motion and generalized weakness of right knee since the surgery.

Intervention: Physical therapy management included modalities and soft tissue mobilization for inflammation and pain control, joint mobilizations, patella mobilizations, contract and relax techniques, manual stretching and low load long duration stretches in order to improve mobility. Isometric and isotonic exercises focused on increasing quadriceps activation and hip strength. Balance and gait training was provided to improve functional mobility.

Outcomes: Patient showed improvements with pain level, range of motion, strength, flexibility, gait, and Lower Extremity Functional Scale. At discharge, patient reported no pain. Right knee flexion was equal to 124° improved from 89° and right knee extension improved to -3° from -10°. Patient had varying results and fluctuations in his range of motion throughout treatment, but overall showed mobility gains. LEFS at initial visit was 25/80 and improved to 43/80 upon discharge.

Discussion: Patient presented with complex knee injury following ACL reconstruction and meniscal repair and as a physical therapy student, this patient case required significant clinical reasoning and monitoring. Overall patient responded positively to a combination of knee mobility interventions. The interventions that resulted in the most in-session gains included Proprioceptive neuromuscular facilitation contract-relax technique to hip flexor group and low load long duration stretch to the hamstrings. There is little literature on treating a patient with a multiple ligament knee injury. This case report demonstrates the importance of completing test/retest following each intervention to assess for tissue and joint irritability in order to progress patient appropriately. Further research needs to be completed to investigate effectiveness of treatments for multiple ligament knee injuries.

Introduction

The knee is an anatomically complex joint that is heavily involved in locomotion, activities of daily living (ADLs), work function and recreational activities. Therefore, impairments to the structures of the knee may result in severe dysfunction. The knee consists of two important joints; the tibiofemoral joint, formed by the articulation of the femur and tibia, and the patellofemoral joint, formed by the articulation between the femoral condyles and patella [1]. The extra-articular and intra-articular ligaments of the tibiofemoral joint play a major role in knee stability [1], whereas, the medial and lateral menisci are important for lubrication, nutrition, improving joint congruency and reducing friction to decrease cartilage wear and tear [2].

Between 1999 and 2008, the United States Emergency Department estimated 2.5 million sports-related knee injuries annually [3]. Knee sprains and strains were amongst the most common diagnosis (42.1%) and the highest injury rate was amongst those age 15 to 24 years of age [3]. A separate 10-year study on athletic knee injuries assessed 17,397 patients with sports injuries and found 20% involved the anterior cruciate ligament (ACL), 10.8% involved the medial meniscus, 7.9% involved the medial collateral ligament (MCL), 3.7% involved the lateral meniscus, 1.1% involved the lateral collateral ligament (LCL), and 0.65% involved the posterior cruciate ligament (PCL) [4]. The most common activity resulting in these injuries was soccer (35%) [4]. Arom

et al reported that multiligament knee injuries occur at a rate of 0.072 per 100 patient-years [5,6].

Multiple Ligament Knee Injuries (MLKI) represent a spectrum of knee injuries involving the ligamentous structures that provide stability for the knee joint and can present with concomitant injuries involving the capsule, tendon, menisci, bone, nerve, blood vessels and cartilage. MLKI range from an injury to one cruciate ligament and one collateral ligament, one cruciate ligament and the posteromedial corner (PMC) (MCL, posterior oblique ligament) or posterolateral corner (PLC) (LCL, popliteal tendon, popliteofibular ligament, fabellofibular ligament, arcuate ligament) or to all four ligaments. MLKIs are classified using the "Schenck Classification of Knee Dislocations (KD)" (Table 1) [7,8].

Currently, surgical intervention for MLKI is superior to non-operative treatment resulting in better functional and clinical outcomes

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Table 1. Schenck classification of knee dislocation (KD) [7]

Type	Description
I	Single Cruciate & PMC Or PLC Injury (I.E. ACL & MCL)
II	Bi-Cruciate Injury (I.E. ACL & PCL)
III-M	Bi-Cruciate Injury With PMC (I.E. ACL, PCL & MCL)
III-L	Bi-Cruciate Injury With PLC (I.E. ACL, PCL, LCL & PFL)
IV	Bi-Cruciate Injury With PMC & PLC
V	Multiligament Knee Injury With Peri-Articular Fracture

[9]. For injuries involving the ACL or PCL, anatomic reconstruction is common, with autograft bone-patellar tendon-bone graft being the most common for ACL reconstruction [10]. Since these injuries involve multiple ligaments, it is important for physical therapists to understand the surgical intervention used when creating a post-operative rehabilitation plan. Postoperative rehabilitation considerations can be mirrored from well-established and published protocols since they yield good long-term results [10]. Rehabilitation plan following surgical intervention should be focused on protection of the graft and functional outcomes, such as, restoring range of motion, strength and gait [11]. Early management should involve supportive measures for inflammation control, pain modulation, and restoring range of motion through joint mobilization, muscle activation and gait training [11].

Due to the complex nature of this patient population, Physical therapists must understand complications associated with surgical intervention for MLKIs. Vascular and nerve injuries are common complications, along with extravasations, compartment syndrome, tourniquet wound complications, heterotopic ossification, and femoral condyle osteonecrosis [12]. Common complications related to physical therapy management of MLKIs include anterior knee pain, loss of motion and persistent laxity [12].

If patellar autograft is used for reconstruction, anterior knee pain may result due to harvesting of the ligament, patella tendonitis, infrapatellar contracture, or intratendinous calcification [12]. Postsurgical stiffness and loss of knee motion is a significant concern due to immobilization during the early protection phase [10], due to scar formation, fibrous adhesions or tension from graft placement [12]. Involvement of the MCL or meniscal repairs further predisposes the knee to loss of motion. Full knee range of motion is pertinent for good long-term outcomes and patients should aim for 0-90° knee flexion 2 weeks post-surgery [11]. Patient may experience significant functional deficits and gait abnormalities with loss of knee extension greater than 5°. Sitting, squatting, navigating stairs and running may be difficult if loss of knee flexion is greater than 110°. Failure to address knee mobility deficits can result in arthrofibrosis. Arthrofibrosis is a rare complication following ACL reconstruction that affects ~2% of patients, but does seem to respond to appropriate interventions [13]. Therefore, it is important Physical therapists limit the effects of immobilization and create a comprehensive plan of care to prevent these complications.

Due to the low incidence of multiple ligament knee injuries, evidence supporting the management of MLKI is lacking. There is a scarcity of high-quality evidence, no randomized controlled studies to date [10] and evidence is limited to case series. Physical therapists may use existing protocols for ACL reconstruction, PCL reconstruction and meniscal repairs as guidelines for treatment as they are well researched. Lastly, due to complexity of multiple ligament knee injuries rehabilitation considerations require focus on tissue and joint irritability; therefore, assessments and reassessments throughout treatment will be important.

The purpose of this case report is to provide a student physical therapist's prospective in managing this type of injury and the clinical decision making process used to choose the most effective physical therapy intervention to restore knee mobility following surgical intervention.

Case description

Subject description/history and systems review

Completed by clinical instructor, physical therapist with 4 years of experience, with minimal assistance from student physical therapist.

The patient is a 21-year-old Hispanic male referred to physical therapy by an orthopedic surgeon nine weeks status post elective ACL autograft bone-tendon-bone (BTB) reconstruction using the patellar tendon, medial/lateral meniscal repair and debridement of synovitis multiple compartments and sprain of the right posterior cruciate ligament (PCL). Patient reports most recent injury occurred while playing soccer when the right foot was stuck in the grass and the knee twisted as patient tried to move it. His chief complaints post-op were dull ache with motion in right knee, limited range of motion with tightness, stiffness and generalized weakness of right knee since the surgery. Additionally, he reports numbness along incision site and occasional LE cramping with muscle spasms to the gastroc-soleus complex. Patient is currently a student and also works as a cook at the local baseball stadium, completing tasks involving prolonged standing, bending and lifting. Due to surgery, patient had difficulties with workload due to sharp pain at knee with work duties and was unable to participate in recreational activities, such as, soccer per healing timeline of condition. Per surgical report, patient had longstanding knee issues; however, during the initial evaluation patient did not go into detail about knee condition prior to surgery.

This patient had no known significant past medical history. At the time of initial evaluation, patient reported he was not taking any medication.

The patient's initial goals for physical therapy were to improve range of motion in his right knee and return to soccer within 1 year.

Examination

A doctor of physical therapy with 4 years of experience completed the initial examination with the assistance of this student physical therapist.

Observation and structural inspection: Patient presented in the clinic full weight bearing without a brace or assistive device. In standing patient presented with forward head posture, rounded shoulders, decreased thoracic kyphosis, increased lumbar lordosis, anterior pelvic tilt, pes cavus, bilateral genu varus and increase weight bearing to right lateral heel/foot. Patient presented with limited scar mobility along patellar tendon incision site.

Pain: Using the Numeric Pain Rating Scale (NPRS), with 10 being the worst pain imaginable and 0 being no pain. Patient reports with dull ache in right knee rated at 4/10 that worsens to 7/10 with bending and lifting activities. Piva et al assessed the responsiveness of the NPRS with patient suffering from patellofemoral pain and demonstrated 95% confidence with use of this scale and a minimal clinical important difference of decrease by 1.16 pts [14]. At discharge patient presented with pain 1/10 indicating positive response to physical therapy.

Palpation for condition: Patient presented with minor swelling of right knee with knee flexion contracture and muscle atrophy of

right quadriceps muscle. Circumferential measurement around mid-patella using standard tape measure was complete bilaterally to assess swelling. Patient presented with right knee at 39.5 cm and left knee 39.0 cm). Muscle atrophy was measured using circumferential girth measurement 5 cm above joint line around bulk of vastus medialis muscle. Patient presented with 34 cm on right and 41 cm on left.

Range of motion: At the initial examination, active range of motion (AROM) of the knee was assessed using goniometric measurement per Norkin [15] with fulcrum over lateral epicondyle, stationary arm directed towards greater trochanter and moving arm directed towards the lateral malleolus. Passive range of motion was measured in the same manner with manual guidance from therapist further into motion as tolerated by patient. Knee flexion was measured in supine with patient on plinth and knee extension was measured in same position with rolled hand towel placed under distal lower leg. Patient demonstrated within normal limits of left knee flexion and extension. Right knee flexion AROM exhibited 89°, PROM exhibited 90° and knee extension AROM exhibited -10° and PROM of knee extension was within normal limits.

Using goniometers is the one of the most common practices to measure knee joint range of motion. Systematic review of psychometric properties of measurement to quantify knee joint position and movement showed strong correlation of criterion related validity between visual estimate techniques and use of plastic goniometers ($r > 0.80$) [16]. The study also demonstrated standardized measurement protocols specified by Norkin were found to be reliable for intertester reliability, intratester reliability, inter-device reliability and test-retest reliability [16]. The reliability was greatest when measurements were completed by the same tested under a controlled environment using standardized testing protocols, in this case Norkin. Since the SPT completed all the measurements for this patient the intratester reliability is high.

Accessory motion of the patellofemoral joint was assessed per Paris technique [17] with patient supine and knee flexed in loose pack position with small rolled towel under knee. Patient presented with considerable hypomobility in all directions (medial, lateral, superior and inferior glide) of right knee with capsular tightness end-feel. Left patellofemoral joint accessory motion was normal in all directions.

Muscle length: Muscle length test of hamstrings was completed in hamstring 90-90 position and patient exhibited - 20° of knee extension bilaterally. Normal hamstring length in this position is at least - 10°. Gajdosik et al compared four clinical test assessing hamstring muscle length and concluded that in the supine hamstring 90-90 position with therapist passively stretching patient into knee extension, a measure of maximal length of hamstrings was being measured [18]. Ober's test per Kendall [19] technique was within normal limits bilaterally. Thomas test and gastroc-soleus complex muscle length testing was not completed during initial evaluation due to time constraints.

Muscle strength: Manual muscle testing was completed for the hip and knee as described by Kendall [19]. Patient was able to tolerate resistance in test position for all muscles tested. Hip flexion, knee extension are completed in sitting position; hip extension and knee flexion were completed in prone position and hip abduction was completed in sidelying. Right hip flexion was 4+/5, hip extension and hip abduction were 4-/5. Left hip flexion was 4/5, hip extension was 4-/5 and hip abduction was 4+/5. Right knee flexion and extension were 4-/5 and left knee flexion and extension were 5/5.

Gait analysis: Patient did not present with knee brace or assistive device. He had full weight-bearing status but was apprehensive with

weight-bearing through right lower extremity. He demonstrated an antalgic gait with shortened stride length. He lacks full right knee extension at heel strike as well as, early heel rise during midstance with limited push off in terminal stance.

Palpation for tenderness: Palpation revealed tenderness along distal portion of incision with reports of slight numbness with palpation

Neurovascular: Patient presented with intact and normal lower extremity sensation.

Outcome measure/function: Lower Extremity Functional Scale (LEFS) was used to determine patient's perceived level of disability due to knee pain. It is a well-validated instrument to assess lower extremity function with varying musculoskeletal disorders. LEFS score was 25/80 at initial evaluation. For the LEFS, the lower the score the greater the disability. Binkley et al demonstrated that the LEFS had excellent test-retest reliability, with the minimal detectable change (MDC) equal to 9 scale points and the minimal clinically important difference (MCID) equal to 9 scale points [20]. At discharge, patient had an LEFS score of 43/80 indicating positive improvements in lower extremity function following physical therapy treatment.

Patient evaluation

Patient presents with signs and symptoms consistent with R knee hypomobility due to capsular tightness of patellofemoral joint and R knee quadriceps & hamstring weakness due to status post ACL BTB reconstruction, medial/lateral meniscal repair and debridement of synovitis of multiple compartments. Primary impairments include muscle atrophy of right quadriceps with minor edema along tibiofemoral joint, capsular tightness at the tibiofemoral joint, decreased range of motion of right knee in flexion and extension, hypomobility of right patellofemoral glides in all directions due to capsular tightness, decrease muscle length of bilateral hamstrings and right lower extremity weakness in hip extension, flexion, abduction and knee extension and flexion. Secondary impairments include minor numbness along distal incision site since surgery and decreased balance in single leg stance bilaterally. Due to the above impairments, patient had difficulty performing functional activities, such as, standing for 1 hour, ascending and descending 10 stairs, getting in and out of car his car, squatting, lifting objects from floor and is unable to participate in recreational activities, such as, soccer or work at full function.

The primary and secondary impairments are consistent with three practice patterns of the American Physical Therapy Association's Guide to Physical Therapy Practice [21]: Pattern 4D Impaired Joint Mobility, Motor Function, Muscle Performance, and Range of Motion Associated with Connective Tissue Dysfunction; Pattern 4E Impaired Joint Mobility, Motor Function, Muscle Performance, and Range of Motion Associated with Localized Inflammation; Pattern 4I Impaired Joint Mobility, Motor Function, Muscle Performance, and Range of Motion Associated with Bony or Soft Tissue Surgery.

Plan of care

Physical Therapy was aimed at improving knee mobility and stability with interventions of stretching, joint mobilization and strengthening. First short term goal for the patient was to be independent with home exercise program to improve right knee stability. The other two short term goals were aimed at increasing right knee extension to 5 degrees to improve stability in stance phase and increasing right knee flexion to 110 deg to improve foot clearance with swing phase of gait. It was anticipated that all short-term goals (STGs) would be met in three

weeks. STGs would help achieve long-term goals and were aimed at improving ambulation without compensations by week 6. The first 2 long term goals involved increasing right knee flexion to 120 degree to improve foot clearance with swing phase and increasing right knee extension to 0 degree to improve stability in stance phase. Other long term goals were to improve bilateral single leg stance with eyes closed for 30 seconds without loss of balance and increasing right lower extremity strength to 5/5 to improve stability with functional activities of daily living, such as, bending to lift items >25 pounds.

It was recommended the patient begin treatment for 2-3 visits per week for 6 weeks to address swelling, scar tissue restrictions and mobility deficits following surgical procedure, balance and gait training, as well as, strength impairments of the right lower extremity.

The prognosis for this patient was determined to be good given his young age and overall good health status with no co-morbidities or complicating medical history. Patient was also highly motivated to improve his range of motion, in order to return to playing soccer in one year. However, physical therapy treatment for this patient was complicated due to prior history of knee condition and complex surgical history, including, ACL autograft BTB reconstruction, medial meniscal repair and debridement of synovitis. Physical therapy protocols for ACL autograft BTB Reconstruction [22] using patellar tendon and Meniscal Repair [23] from the Brigham and Women's Hospital Department of Rehabilitation Services were used as a guideline for expected patient goals and outcomes during the post-operative phase. This protocol was chosen because it was the typical protocol used by the facility and protocol recommended by clinical instructor.

Due to the involvement of the anterior cruciate ligament, posterior cruciate ligament, lateral meniscus and medial meniscus, expected progression regarding range of motion (ROM), tissue healing, pain and effusion were more challenging to predict. Since rehabilitation for ACL reconstruction and MCL repairs are well researched, these protocols can be an excellent guideline to assist with clinical decision making for this complex patient. Initial treatment strategy for the patient included post-surgical intervention to reduce pain, decrease inflammation, and increase range of motion, eventually progressing to strengthening LE, improving proprioception, balance, and normalizing gait.

It is hypothesized that the right knee pain along the distal incision site and joint mobility restrictions in both the patellofemoral joint and tibiofemoral joint in all directions are related to immobilization, possible infrapatellar contracture [12], edema in the tibiofemoral joint and development of scar tissue adhesion following surgical procedure. It is assumed that since a patellar tendon graft was used, scar tissue formation along the graft site would limit superior glide therefore limiting knee extension. Specific interventions were chosen to address the aforementioned impairments. The initial focus of physical therapy was to improve scar tissue mobility along incision site, decrease patellofemoral joint and tibiofemoral joint capsule restriction in all directions and increase hamstring/quadiceps muscle length in order to improve right knee flexion and extension. To achieve these goals manual therapy consisting of transverse friction massage, Grade I - IV anterior and posterior glides of the tibiofemoral joint, Grade I-IV patella joint mobilizations in all directions, passive stretching to the hamstring, quadriceps, iliopsoas and gluteal muscles, tack and stretch to the hamstring muscles, low load long duration stretch to the hamstrings, contract-relax/hold-relax technique and gentle knee flexion/extension PROM/AAROM exercises were used. Immobilization following surgery will also result in muscle weakness due to disuse atrophy. The second focus of therapy was to improve knee stability through new

range by increasing right lower extremity knee flexion, knee extension, hip extension, hip flexion and hip abductor strength and incorporating balance and gait training to decrease gait deviation of decrease stride length, lack of proper heel strike, early toe off in midstance and limited push off in terminal stance. Strengthening exercises involved isometric and isotonic exercises, as well as, closed chain exercises. Due to muscle weakness of the right quadriceps and hamstrings, resulting in lack of knee stability, strengthening exercises were initiated early as part of patient's home exercises program. Strengthening exercises involved isometric exercises for the quadriceps and hamstrings, isotonic exercises to increase hip flexor, hip extensor, hip abductor, knee flexor and knee extensor strength, as well as, closed chain activities to work on functional stability.

Implementation of interventions

The patient's insurance company approved a total of 12 visits of skilled physical therapy including the initial evaluation. Depending on availability of appointments, patient came in 2-3 times a week for 45 to 60-minute sessions. He remained compliant with treatment sessions throughout entire episode of care with no large breaks in between. At least one day in between each treatment session was recommended to allow for appropriate recovery time.

Week 1 (Visits 2-4) began with patient lying supine on a high-low table with small pillow roll underneath the right knee due to patient's inability to rest in full extension, requiring support in knee flexion to decrease pain. Superficial effleurage with Biofreeze pain relieving gel was performed for 2-3 minutes to right knee starting from distal to proximal lower leg to decrease swelling and relax tissues. Following effleurage, gentle scar mobilization was completed along the same grain as the incision site as tolerated by patient. Following scar mobilization, Grade I patellar joint oscillations in medial and lateral direction were completed according to Paris technique [1]. If tolerated with no aggravation of symptoms, Grade II/III patellar joint mobilizations were completed in all directions (superior glide, inferior glide, medial glide and lateral glide) according to Paris [17] technique in order to improve mobility into both knee flexion and extension. Since patellar tendon graft was used restoring loss of mobility to patellar tendon was very important.

This was followed by gentle PROM exercises for knee flexion and extension 3 sets x 10 reps within pain free range progressed to AAROM per Kisner and Colby [24]. Following manual therapy techniques, knee flexion and extension range of motion were assessed using goniometric measurements per Norkin [15]. See Table 2 for post treatment measurements. Kumar [25] compared the effectiveness of continuous passive motion vs. joint mobilization in treating knee stiffness. The comparative study found that those who followed a PT regimen with moist hot pack, continuous passive motion, joint mobilizations and exercises demonstrated the most improvements in ROM and functional performance for post-operative knee stiffness.

Table 2. Knee range of motion assessment after treatment sessions

	Post-Treatment Knee Flexion	Post-Treatment Knee Extension
Week 1 (Visit 2-4)	100 deg	- 10 deg
Week 2 (Visit 5-7)	112 deg	- 8 deg
Week 3 (Visit 8)	115 deg	0 deg
Week 3 (Visit 9)	118 deg	- 3 deg
Week 4 (Visit 10)	122 deg	-1 deg
Week 4 (Visit 11)	124 deg	0 deg
Week 4 (Visit 12)	124 deg	- 3 deg

Following the above, manual stretching techniques were completed for the right hamstring and quadriceps muscles. Contract relax technique as described by Adler [26] was performed. Per Morcelli, contract-relax stretching technique provides immediate flexibility gain of the hamstring muscles [25]. For hamstring, patient remained supine and hamstring was brought to end range of stretch, where distal leg was resting on therapist shoulder. Patient was instructed to perform a submaximal isometric contraction holding for 8 seconds, followed by a period of rest where therapist brought leg further into range as tolerated by patient. Between every 3rd repetition, patient was asked about tolerance to stretch and further stretching was continued if gains in muscle length were still achieved or discontinued if no more gains were achieved. Same technique was applied to quadriceps in Thomas test position on high low table.

Following manual stretching, patient completed heel slides using strap over anterior shin to assist into knee flexion. Patient was instructed to complete 3 sets using the following sequence, per clinical instructor (CI) recommendation on July 18, 2017 at 11:15 am: 1st set: 10 repetitions x 1 sec hold at end range of flexion; 2nd set: 10 repetitions x 3-5 sec holds at end range flexion; 3rd set: 10 repetitions x 7 sec holds at end range knee flexion. This was followed by static hamstring stretch in long sitting position 3 sets x 30 repetitions with non-stretched leg on floor for stability. Patient was instructed to place hands on distal femur to further assist into knee flexion as tolerated.

Treatment ended with guided supervision of short arc quads, straight leg raise in 3 planes, sidelying hip abduction and prone hip extension exercises 2 sets x 10 repetitions with cues to maintain knee extension and prevent extension lag, especially with straight leg raise.

Patient tolerated above interventions well noting positive response following the first week of treatment. Following skilled physical therapy treatment, patient reported a decrease in sharp pain along incision site and decrease in knee stiffness. By the end of the first week (visit 4), he continued to report pain along patellar incision site with extension activities and weight bearing activities. Due to ACL autograft BTB reconstruction, it is expected that patient would have more patellofemoral complications due to scarring of these areas [27]. During visit 4, treatment was modified to include moist hot pack to reduce pain, increase circulation and improved tissue extensibility as a preparatory technique for manual techniques [28]. MHP was combined with interferential current [29] using sweep scan with 2" x 2" electrodes criss-cross over the right knee with legs supported on bolster to reduce pain x 10 minutes.

Following MHP and IFC treatment, patient was asked to perform one short arc quad and straight leg raise following each of the manual techniques described above to assess if pain would reduce. The interventions as described above reduced sharp pain at rest, but were not effective at reducing pain with active knee extension. Per CI guidance, tibial distraction was provided during short arc quad and patient reported a reduction in symptoms with this technique.

Furthermore, it was hypothesized that adhesions at graft site may possibly be contributing to pain due to decreased knee motion, so patient was instructed to include scar massage [30,31] pre-stretching tissue with one hand at distal quadriceps and using two fingers along grain of incision site as tolerated to his home exercise program.

During week 2 of treatment (Visits 5-6) patient reports improvement in sharp pain, but continued to have sharp pain along incision site with right knee extension activities rated at 1-2/10 using numeric rating

scale. He continued to respond well to treatment noting 5 degrees of improvement in knee flexion following interventions prescribed during week 1. Patient saw orthopedic surgeon prior to visit #6 and was instructed to focus on increasing knee extension to 0 degrees. Patient also returned to work full time noting that his job as a cook involved prolonged standing for 45 minutes at a time with breaks to walk around. He noted no increase in knee symptoms following return to work, but continued to have sharp pain along incision site with weight bearing. Due to increased sensitivity along incision site, patient could not tolerate patellar mobilizations although he continued to present with restrictions in all directions. Due to other impairments student physical therapist wanted to address that day, patellar mobilizations were omitted during that treatment session.

Due to continued limitations in knee extension range of motion between visits 3 and 5 treatment was modified to address muscle length restrictions of hamstrings and tibiofemoral joint restrictions, in order to improve knee extension since patient was unable to tolerate patellar mobilizations due to pain. Patient was placed in a prone position with knee off plinth. Tack and stretch technique was completed with tack provided using sustained pressure with thumb at hamstring muscle belly, while other hand was providing gentle stretch into knee extension x 10 repetitions. Tolerance to stretch was assessed after each 10 repetitions and 3-4 sets were completed until no more flexibility gains were reached. Following tack and stretch, knee extension range of motion was reassessed using goniometric measurement following Norkin [15] technique with patient in supine with distal ankle on half foam roll. The purpose of reassessment was to test effectiveness and patient response to intervention. Two degrees of knee extension was gained following tack and stretch of hamstrings. This was followed by a low load long duration (LLD) prolonged stretch using a 4 lb ankle weight at distal ankle for 5 mins. Following LLD stretch, knee extension range of motion was reassessed using Norkin [15] technique with half foam roll placed at distal ankle. Patient gained a total of 5 degrees of knee extension. This was the largest ROM gain made after a single intervention compared to previous joint mobilizations, range of motion or stretching techniques provided. Due to the positive patient response, this intervention was continued.

In order to increase knee flexion range of motion Grade III tibiofemoral joint mobilization in A/P direction x 10 repetitions and talar tilt x 10 repetitions was completed following Paris [17] technique due to hypomobility noted at tibiofemoral joint. This technique was completed 2-3 times based on patient tolerance. Goniometric measurement for knee flexion range of motion using Norkin [15] technique was used to assess mobility gains following intervention. 7 degrees of knee flexion range of motion was achieved following this intervention and due to positive gains, intervention was continued.

At the end of week 2, patient was instructed to use LLD hamstring stretch at home in long sitting position with ankle weight (3-5#) at distal femur x 10 minutes.

By Week 3, patient was beginning to report decrease in pain with no reports of sharp pain noted along incision site and improvements in right knee stiffness during ambulation. Since patient does not have ankle weight, he was unable to complete LLD hamstring stretch as part of home exercise program. Modified long sitting hamstring stretch to seated at edge of mat with patient providing additional manual push into knee extension at distal femur holding for 30 seconds for 3 reps, 3 times a day. Patient remained compliant with HEP, completing exercises 3 times a day.

Throughout week 3, patient responded well to LLD hamstring stretch and tack and stretch techniques to increase knee extension. However, he presented with inconsistent responses to mobility techniques to improve knee flexion range of motion. Right knee flexion range of motion was assessed following each mobility technique in order to determine effectiveness. On visit 8, contract relax to quadriceps and hip flexor in Thomas stretch position was more effective at increasing knee flexion range of motion then grade III tibiofemoral A/P joint mobilizations. By the end of week 3, (visit 9), patient demonstrated improvements in knee range of motion, but continued to present with hypomobility of patellofemoral joint in superior glide, inferior glide, medial glide and lateral glide and tibiofemoral joint in A/P and P/A directions. By the end of week 3, due to improvements in mobility patient was able to complete functional activities such as stairs and getting in and out of his car with no reports of pain to his right knee only soreness.

During week 4 (visits 10-12), patient worked with on-site physical therapist assistant for visits 10 & 11. Same interventions were carried out with introduction of recumbent bike x 10 minutes at the beginning of treatment session for warm up. LLD hamstring stretch in prone was progressed with addition of 2# ankle weights and 1 minute added to treatment each visit, as tolerated by patient.

Although strengthening exercises were completed throughout treatment, the main focus for this patient was to restore normal range of motion first because strength gains cannot be achieved with limited ROM. The literature supports that there is an increased prevalence of osteoarthritis following anterior cruciate ligament reconstruction. However Shelbourne [32] found that those who were unable to restore normal knee range of motion were at even higher risk for developing osteoarthritis. However, strengthening program was slowly progressed throughout entire treatment period as tolerated by patient. Strengthening interventions were completed after manual therapy treatment. Following SAQ, SLR, prone hip extension and sidelying hip abduction, standing toe and heel raises were added to strengthen gastroc-soleus complex. Once pain with weight-bearing activities were decreased, patient progressed to closed chain strengthening including wall sits, standing terminal knee extension with theraband, and single leg squats.

Gait training was completed using step over cone activities emphasizing heel toe gait pattern with verbal cues for toe off (Table 2).

Outcomes

At time of discharge, patient made positive gains towards goals and functional abilities. He had returned to work full time with only minimal difficulty noted, such as, lifting heavy objects (>25 lbs) off the floor and right knee soreness at the end of his shift, but no reports of pain. At initial evaluation, Lower Extremity Functional Scale (LEFS) result was 31.25% (25/80 points) indicating low function due to impairment. At discharge LEFS result was 53.75% (43/80 points) indicating moderate function due to impairment. Per Alcock, *et al.* [33], the LEFS “demonstrated excellent test-retest reliability” for population undergoing anterior cruciate ligament reconstruction surgery. Minimal detectable change in Lower Extremity Functional Scale for ACL reconstruction is 8.7 [34] per Alcock *et al* and patient showed >20% improvement indicating clinical significance.

Overall, the patient showed increase in right tibiofemoral joint flexion and extension range of motion since the initial evaluation (Table 3), but still presented with some limitation in active knee extension range of motion. Hamstring muscle length of right lower extremity was

still limited at 15° by discharge using the 90/90 hamstring flexibility test per Kendall [19] compared to normative values. The patient also demonstrated elimination of tibiofemoral joint swelling as measured around mid-patella with patient in supine and increased quadriceps/VMO muscle bulk using girth measurements approximately 5 cm proximal to mid-patella (Table 4). Pt demonstrated improvements in muscle strength of right hip and knee as displayed in Table 5. Patient improved his static balance in single leg stance with eyes open on right lower extremity, but continued to have difficulty with single leg stance with eyes closed. Lastly, patient demonstrated improvements in heel toe gait pattern, weight bearing through R LE, decrease in apprehension and improved stride length and push off. Patient was able to return to work half way through treatment sessions with no adverse reactions with work duties.

Patient would have benefited from additional physical therapy to make further gains in his range of motion, strength, balance and overall function in order to return to recreational activities. He was discharged to his home exercise program, which included interventions targeted at strengthening his quadriceps, hip abductors and hip extensors, as well as, stretches to target the hamstrings, hip flexors and gastroc-soleus complex. Patient was instructed to contact doctor or physical therapist should symptoms return.

Discussion

This case report demonstrates the complexity of post-surgical rehabilitation when multiple extra-articular and intra-articular structures of the knee are involved and the multimodal approach taken to identify the most effective intervention in regaining knee mobility. The patient had involvement of the right PCL, ACL, lateral meniscus and medial meniscus. Since the ACL was more vulnerable because it underwent reconstruction, ACL protocols were followed. Patient was progressed based on patient tolerance with respect to reconstruction, as well as, precautions towards the sprained PCL and lateral/medial meniscus repair.

One of the most common complications following ACL reconstruction, include loss of knee extension range of motion, anterior knee pain, infrapatellar contracture, patella tendonitis [12]

Table 3. Knee range of motion (Initial evaluation vs. Discharge)

	Knee Flexion AROM	Knee Flexion PROM	Knee Extension AROM	Knee Extension PROM
Initial Eval	89 degrees	90 degrees	-10 degrees	0 degrees
Discharge	124 degrees	127 degrees	- 3 degrees	0 degrees

Table 4. Girth measurements for swelling and muscle atrophy (Initial evaluation vs. Discharge)

	Mid-Patella (Swelling)		5 cm above mid-patella (Muscle Atrophy/Bulk)	
	Right	Left	Right	Left
Initial Eval	39.5 cm	39.0 cm	34 cm	41 cm
Discharge	38.5 cm	38.5 cm	41 cm	43 cm

Table 5. Muscle strength tests (Initial evaluation vs. Discharge)

	Right		Left	
	Initial Eval	Discharge	Initial Eval	Discharge
Knee Flexion	4-/5	5/5	5/5	4+/5
Knee Extension	4-/5	5/5	5/5	4/5
Hip Flexion	4+/5	4+/5	4/5	5/5
Hip Extension	4-/5	4/5	4-/5	5/5
Hip Abduction	4-/5	4+/5	4-/5	5/5

or arthrofibrosis [35]. Loss of knee extension greater than 5° can significantly affect function, result in gait abnormalities and contribute to quadriceps weakness [35]. Adams, *et al.* reports that 25.3% of patients have more than a 5° side to side difference 4 weeks after ACL reconstruction [35]. ACL Early Postoperative Phase (status post 2 weeks) suggests that patient should be achieving the following criteria: full active/passive extension/hyperextension of range of motion [22]; "knee flexion greater than 110, walking without crutches, use of cycle/stair climber without difficulty, walking with full knee extension and no extensor lag with straight leg raise [35]." Once ROM criteria are met and quadriceps strength gains are greater than 60%, rehabilitation considerations should be focused on restoring balance and neuromuscular re-education to prevent weakness or muscle atrophy.

The patient presented 9 weeks status post ACL reconstruction and lateral/medial meniscal repairs without formal therapy and therefore did not present with expected range of motion post operatively. He was not receiving Physical Therapy prior to his initial evaluation due to delay in insurance authorization putting him at risk for arthrofibrosis. The student physical therapist expected the patient to present with signs and symptoms of capsular tightness and scar tissue adhesions due to immobilization since surgery. Based on Classification of Arthrofibrosis following ACL Reconstruction, Shelbourne et al would categorize this patient as a Type 3 level of arthrofibrosis due to knee extension >10 degrees and greater than 25% loss of knee flexion [36].

The physical therapy student prepared for this case by identifying the appropriate phase of rehabilitation using protocols from the Brigham and Women's Hospital for ACL Reconstruction and Meniscal Repairs, as well as, postoperative management of ACL reconstruction presented by Kisner and Colby [24]. Due to the complexity of the patient with multiple structures involved, as well as, delay in physical therapy, clinical decision-making and progression through phases was based on criterion opposed to timeline since surgery.

In order to choose the most effective interventions, a thorough examination was completed in order to determine specific tissue impairments contributing to limitation in range of motion. For this particular patient there were a number of contributing factors as a result of his surgery and immobilization following surgery. He suffered from loss of motion due to inflammation in the knee capsule, joint effusion at the tibiofemoral joint, capsular restriction in both the tibiofemoral and patellofemoral joints and tightness in the surrounding soft tissue muscles. Motion loss can even occur due to inappropriate timing of surgery, especially in regards to ligament reconstruction [37]. However, when multiple structures are involved or multiple ligament knee injury is present, immediate surgery may be indicated.

Due to the many tissue specific impairments contributing to this patient's limitation, the student physical therapist learned when providing a specific intervention, it was important to identify if the intended results of that intervention were being achieved. Taking objective measures and recording patient progression with specific details were beneficial in aiding the SPT to identify the appropriate progression in treatment and whether or not plan of care needed to be modified to achieve goals.

Initial goals for this patient focused on inflammation, pain control and knee mobility (involving capsule, articulation, fascia and soft tissue). He demonstrated positive response with improvement in mobility for knee flexion and extension following Grade II-III patellar joint mobilizations in all directions, passive knee flexion and extension, PNF contract-relax technique to hamstrings and quadriceps muscles.

Working theories of knee pain included possible infrapatellar contracture, scar adhesion at graft site and increase patellofemoral pain due to decrease hip strength. Souza and Powers determined that hip kinematics and muscle strength played a role with patellofemoral pain [38]. They correlated that a decrease in hip extension and hip abduction strength may contribute to increase in hip internal rotation and adduction increasing patellofemoral pain. Based on this patient's presentation of knee valgus in standing, and weakness in hip extension (4-/5) and hip abduction (4-/5), hip kinematics could also play a role in his pain. Strengthening exercises were prescribed to home exercise program to address hip strength deficits. In clinic, closed chain activities were completed with special attention to enhance gluteus medius activation and prevent knee valgus in weight bearing. Scar tissue mobilization was also introduced and patient was instructed to complete as part of home exercise program.

About half way through the program, patient went back to see his orthopedic surgeon. At this point in time, plan of care was focused on regaining knee extension range of motion per surgeon's request. Since mobility gains were not remaining consistent between sessions with current interventions, student physical therapist escalated care to supervising physical therapist and physical therapy assistant. Following their recommendation, tack and stretch technique to the hamstring was introduced along with low load long duration (LLLD) stretch to the hamstrings. Since patient still presented with limitations due to capsular restriction and decrease in muscle length, previous interventions were still provided to address these impairments with the addition of tack and stretch and LLLD stretch.

There is limited information in the literature regarding the efficacy of tack and stretch technique, but anecdotal evidence within this case study demonstrates positive correlation. Principles of myofascial release acted as working evidence to support effectiveness of tack and stretch technique. Shah and Kage completed a randomized control trial assessing whether or not active release technique (ART) would improve hamstring flexibility by measuring the popliteal angle [39]. The study defines ART as a treatment taking the involved tissue from a shortened position to a lengthened position, while maintaining manual contact. Based on this definition, the implementation of tack and stretch for this particular patient was almost identical and deemed an appropriate intervention for restoring flexibility in the hamstrings, in turn, improving knee ROM.

An experimental study assessing affects of low torque-long duration stretch on joint contractures demonstrated higher restoration of passive range of motion with this intervention [40]. Other studies that support low load long duration or static progressive stretch demonstrated improvements in range of motion due to arthrofibrosis [41]. However these studies use orthotic devices to complete stretch and time frames as high as 30 minutes. Bonutti, *et al.* utilized principles of static progressive stretch and demonstrated a median gain of 19° in active knee flexion [41]. Therefore, LLLD stretch was deemed appropriate for this patient based on these principles. However, due to the limited time frame in an outpatient clinic and to meet realistic compliance of the patient, the LLLD intervention was modified with a shorter duration (<30 minutes). Since patient demonstrated positive mobility gains following low load long duration stretching, SPT continued to provide this intervention until discharge.

By the latter half of the program, patient began to make steady improvements in range of motion and was able to maintain knee flexion range of motion during follow up sessions; however knee extension range of motion still fluctuated between -3 and 0 degrees.

With improvements in knee mobility, strengthening exercises were progressed to improve knee stability with closed chain activities. Wall sits were especially important with knee flexion at about 60 degrees as this maximizes VMO muscle activation, as well as, standing terminal knee extension with theraband.

Due to varying responses throughout entire episode of care, it is difficult to determine which specific intervention seemed to have the most impact on the patient's mobility. On some days, patient would respond very well to a particular intervention with significant mobility gains and on other days there would be no change in mobility following intervention. For example, patient responded with increased knee flexion range of motion following contract relax technique in Thomas test position, but the following treatment session there were no gains made. It is possible that patient responded well to a combination of all the interventions. Patient was also very motivated and compliant with home exercise program, which could have also contributed to his improvements.

Overall, treatment addressing all possible anatomic structures limiting knee motion resulted in improvements in overall motion and function upon discharge from physical therapy. Due to complexity of patient, it was important to assess and reassess in session changes following interventions in order to obtain objective data to support interventions. It is critical for a SPT to have a multimodal approach and continue to test/retest after each intervention in order to assess patient's response and progress. Patient seemed to respond differently to the same intervention at each visit. It could be that impairments had resolved and patient was making new functional gains/range, therefore, the primary impairment may have changed as the patient was progressing.

In general, all patients are different and will respond differently, even the same injury or diagnosis may be treated in many different ways by the same therapist. It is important for students as well as experienced clinicians to use clinical reasoning (test/retest) and the best available evidence in order to get patients better as fast as possible. There is no cookie cutter approach and protocols can provide us with guidelines for treatments, but clinicians must understand the importance of having multiple tools in one's toolbox and be able to implement this when patients don't respond to conventional methods.

Understanding the importance of testing/retesting and using these findings helped the student physical therapist gain confidence in selecting the most appropriate intervention, amongst a number of interventions that based on the literature would be appropriate to use for this patient's specific impairments. Lastly, it is important to identify when a student physical therapist needs to escalate care to clinical instructor due to lack of patient progression.

This case report provides us with some further knowledge about physical therapy management of multiple ligament knee injuries and the clinical decision making process behind choosing the most appropriate intervention [42,43].

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