Rehabilitation Following Anterior Cruciate Ligament and Posterolateral Corner Reconstruction with Medial and Lateral Meniscus Repairs in A High School Athlete: A Retrospective Case Report

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ABSTRACT

Background and Purpose: Complex and extensive knee injury in athletes pose a unique challenge in rehabilitation. The purpose of this case report was to describe the rehabilitation of a high school athlete who suffered a sport contact injury damaging the anterior cruciate ligament (ACL), medial and lateral menisci, and posterolateral knee compartment. **Methods:** The patient was a 17-year-old male athlete who underwent right ACL reconstruction, medial and lateral menisci repair, and posterolateral knee compartment reconstruction. Seven days postoperatively at initial evaluation he ambulated toe-touch weight bearing, using axillary crutches, with the knee immobilized by a brace locked at 0° extension. Passive knee range of motion (ROM) was 5° to 60°, with strength in available range graded 2/5 via manual muscle test (MMT). The patient was treated for 7 months for a total of 54 sessions. Physical therapy focused on passive and active ROM, therapeutic exercise (progressing from basic to sport specific), neuromuscular re-education, manual therapy, and modalities. **Findings:** At discharge passive ROM was +1-130°, active ROM 0° to 128°, and MMT of all R knee motions were 5/5. From 4 months to discharge isokinetic testing (60°/sec) of peak torque hamstrings to quadriceps ratio increased bilaterally (R LE: 43% to 61%; L LE: 57% to 72%). At discharge isokinetic knee extension peak torque-body mass ratio (180°/sec) was 66% right (R) lower extremity (LE) and 67% left (L) LE, all tibiofemoral stability tests were negative, and the patient returned to sport. **Clinical Relevance:** A 7-month progressive multi-modal rehabilitation plan was able to return a young athlete to sport following a complex and extensive knee injury. **Conclusion:** A progressive rehabilitation plan following extensive reconstructive repair of a complex knee injury was successful in returning an athlete to sport in a short 7-month timeframe.

Key Words: knee rehabilitation, complex knee injury

INTRODUCTION

Injuries to the anterior cruciate ligament (ACL) are prevalent in athletes with an estimated occurrence between 100,000 and 300,000 annually.[1,2] Approximately 50% these injuries are seen in individuals between 15 and 25 years of age participating in high velocity sporting activities.[3] Approximately 30% of ACL injuries occur as a result of external contact forces, and these type of injuries are more commonly associated with injury to secondary knee structures, such as the meniscus, articular cartilage, or the collateral ligaments.[2]

When injury to secondary knee structures occurs concurrently with the ACL, subsequent rehabilitation following surgical reconstruction can be affected. For example, significant tears to and subsequent repairs of the meniscus typically require slower progression of weight bearing (WB), range of motion (ROM), and introduction of therapeutic activity.[4] Concurrent injury to the lateral collateral ligament (LCL), a relatively uncommon occurrence, will also delay rehabilitation progression, with WB being delayed up to 4 weeks and resisted hamstring activation delayed 6 to 8 weeks following surgery.[4]

The posterolateral corner (PLC) of the knee is another secondary injury area of concern with ACL injuries.[5] It is common for injuries to the PLC to be missed as a part of the injury diagnosis, and may therefore be a contributing cause for ACL graft failure.[6-8] The PLC is comprised of the iliotibial band, biceps femoris muscle, LCL, popliteus muscle, popliteofibular ligament, lateral gastrocnemius muscle, lateral joint capsule, coronary ligament, oblique popliteal ligament, and the fabellofibular ligament.[7,9] Injuries to this area of the knee make up 16% of all ligamentous knee injuries.[10] These structures resist varus forces of the knee and rotation of the tibia.[5] Inability to restore PLC function could alter knee biomechanics and result in poor ACL outcomes, leading to early degenerative changes in the knee.[5,10,11] Posterolateral corner injuries typically occur with athletic injuries, motor vehicle accidents, and falls.[7,10]

There is a paucity of research regarding the rehabilitation of patients experiencing concurrent ACL and PLC reconstructive surgery. A systematic review by Bonanzinga et al[10] identified only 6 studies that reported patient outcomes from this procedure, and only 2 of those studies discussed, even in general terms, postsurgical rehabilitation of the patients involved. Return to sports following an isolated PLC reconstruction requires symmetrical strength, stability, and ROM when compared to the contralateral limb, which typically required 6 to 9 months to achieve. Common restrictions in combined ACL and PLC reconstruction rehabilitation protocols include bracing for the first 2 to 4 weeks postsurgery and passive ROM allowed after 1 to 4 weeks.[10-12] Typically after 6 weeks, the rehabilitation protocols follow that of a standard ACL protocol.[10,11]

Myer et al[13] have reported that return to sports following ACL reconstruction generally lacks standardized objective criteria. The decision is often based on graft stability, patient confidence, postsurgical timeline, and the medical team's subjective opinion. Although a return to sport following isolated ACL reconstruction may be possible as early as 3 to 4 months postsurgery, they indicate that athletes may not have sufficient functional stability to prevent reinjury. Functional stability deficits may include decreased muscular strength, joint position sense, postural stability, and force attenuation, and may

be evident for 6 months to 2 years following reconstructions. Standardized objective criteria of functional stability and neuromuscular control may improve successful early return to sports and long-term outcomes.[14]

Cvjetkovic et al[14] state that isokinetic testing can serve as an important objective criterion of dynamic stability of the knee joint and can therefore estimate the quality of rehabilitation outcome following ACL reconstruction. Isokinetic assessment is safe to administer and can detect hamstring to quadriceps ratio imbalances that would call for the delay in an individual's return to sport timeframe.[14] In post-pubescent adolescents and adults, normative values for knee extension peak torque-body mass ratio at 180°/s are 58% to 75% for men and 50% to 65% for women.[13] When determining an objective return to sport timeframe following ACL reconstruction, it is recommended that male athletes achieve an isokinetic (180°/s) testing criteria of 60% knee extension peak torque-body mass ratio, with female athletes achieving a similar criteria of 50%.[13]

While there exists extensive research regarding rehabilitation of isolated ACL injuries, there is considerably less research available on rehabilitation of athletes that have suffered more complex knee injuries, especially to multiple secondary knee structures such as the meniscus and the PLC.[10] The purpose of this case report therefore was to describe the rehabilitation of an athlete who suffered an ACL tear and concomitant injury to both medial and lateral menisci, as well as the PLC, and his ultimate return to sport using objective isokinetic assessment of knee extension performance.

CASE DESCRIPTION

Patient Information

The patient was a 17-year-old Caucasian male athlete who sustained a football contact injury to his right knee that resulted in a complete tear of the ACL, injuries to the medial and lateral menisci, and PLC injury that included the popliteus muscle, popliteal fibular ligament, and the LCL. Radiographs taken immediately after the injury showed no fracture or bony misalignment, but manual examination of the knee suggested a possible ACL injury. Within 24 hours the patient underwent magnetic resonance imaging of the knee that revealed a complete mid-substance tear of the ACL and pivot shift mechanism of injury with deep central sulcus sign along the lateral femoral condyle, bone contusion with microtrabecular fracture along the posterior lateral tibial plateau, complete tear of the lateral head of the gastrocnemius muscle at its musculotendinous junction, complete disruption of the lateral retinaculum of the patella, a vertically oriented peripheral tear in the posterior horn of the medial meniscus, and a similarly oriented tear to the central portion of the posterior horn of the lateral meniscus. The patient underwent arthroscopic reconstruction of the ACL 21 days after the injury that consisted of an autograft from hamstring tendon, medial and lateral meniscal repairs, and open reconstruction of the PLC using a cadaveric Achilles tendon allograft to reconstruct the LCL.

Examination

Physical therapy documentation was attained retrospectively. Seven days postoperatively, the patient presented to physical therapy ambulating using bilateral axillary crutches and restrictions of toe-touch WB, and wore a total ROM knee brace locked at 0° extension. The patient exhibited gross ROM deficits (Table 1), and strength of both hamstrings and quadriceps muscles, measured via manual muscle testing (MMT)[16] within the limited ROM, was 2/5. Edema was not assessed on the initial evaluation secondary to protective incision bandages. Pain was rated using the numeric pain scale at 1/10. Neurological review showed the patient had normal sensation of the bilateral lower extremities (LE). Secondary to the stage of healing no further tests or measures were performed at the time of the initial evaluation. Based on the patient's age, prior health status, motivation, and level of family support it was determined that the patient exhibited a good prognosis for rehabilitation.

Intervention

The patient was treated in physical therapy over a 7-month period for a total of 54 sessions using the surgeon's postoperative ACL rehabilitation protocol (Table 2). The protocol, approximately 7 months in length, was generally divided into 4 rehabilitation phases: (1) early rehabilitation (0-4 weeks), (2) controlled ambulation (4-10 weeks), (3) advanced activity (10-16 weeks), and (4) return to activity (16-30 weeks) (see Table 2).

An initial home exercise program was prescribed (to be performed twice daily) that consisted of quadriceps sets, straight leg raises, sidelying hip abduction (all 3 sets of 10 repetitions), and passive knee ROM (10 repetitions).

During the early rehabilitation phase, the patient was seen in the clinic 3 times per week for a total of 9 treatment episodes following the initial evaluation. Physical therapy interventions (Table 3) included manual therapy and modality interventions to achieve full extension ROM, gradual increase flexion ROM to 90°, increase soft tissue elasticity and extensibility, restore patellar mobility, decrease swelling and pain, improve muscle activation and recruitment, and improve gait mechanics within protocol limits of 30% WB, ambulation using bilateral axillary crutches, and total ROM brace locked in full extension. A NeuroCom® Smart Balance Master system (Natus Newborn Care, San Carlos, CA) was introduced in treatment to assist the patient in objectively progressing WB status. As the patient progressed to postoperative week 4, he began to experience increased calf pain. The patient was instructed to return to non-WB and the physician was contacted. A Doppler scan was ordered secondary to concern for deep venous thrombosis because of the patient's signs, symptoms, and length of time since surgery. The results of the Doppler scan were negative, and the patient was instructed to return to 30% WB. During postoperative week 4, the patient had progressed as scheduled per protocol having achieved normal patellar mobility, 0° to 90° tibiofemoral active ROM, and ambulation at 30% WB

Table 1. Knee Range of Motion for the Patient

Right Knee	Initial	Discharge
Active Tibiofemoral Flexion	Not Assessed	128°, symmetrical to left
Active Tibiofemoral Extension	Not Assessed	0°, symmetrical to left
Passive Tibiofemoral Flexion	60°	130°, symmetrical to left
Passive Tibiofemoral Extension	5° extension lag	+1°, symmetrical to left
Patellofemoral	Decreased	WNL, symmetrical to left

Abbreviation: WNL, within normal limits
ROM assessment made via goniometry[15]

Table 2. Postoperative Rehabilitation Stages

Early Rehabilitation Phase: 0-4 weeks Restricted ROM: 0 to 90º Partial WB 30% x 4 weeks Brace locked in 0º extension during ambulation
Controlled Ambulation Phase: 4-10 weeks Progress to full ROM
Progress WB to Full WB week 6 and discharge axillary crutches Unlock brace at week 6 Advance to Playmaker brace at week 8
Advanced Activity Phase: 10 to 16 weeks
Continue to Progress to full ROM
Normalize Gait Progress muscular strengthening/stability training
Initiate light intensity plyometric training Initiate multi-directional plane activity
Return to Activity Phase: 16 to 30 weeks
Progress muscular strengthening/stability training
Progress to Donjoy custom fit Defiance brace®
Initiate Running Program Progress to Sport-Specific Training Initiate Isokinetic Testing
Abbreviations: ROM, range of motion; WB, weight bearing

Table 3. Early Rehabilitation Treatment Protocol

Week	Interventions
0-1	Postoperative week 1 included physician instructed HEP and cryotherapy application. Physical therapy plan of care established.
1-2	Active-assistive/passive ROM, open kinetic chain hip concentric exercises, Multi-angle quadriceps/hamstring isometrics, ankle pumps, patellar mobilizations, NMES – Burst modulated AC (Russian) at maximum tolerable intensity, Game Ready Cold Compression.
2-3	Continued with previous interventions, Lower body ergometer cycle, non/partial-weight bearing wall slides, pro-long static stretching, soft tissue mobilization, NMES – Burst modulated AC (Russian) at maximum tolerable intensity, Game Ready Cold Compression.
3-4	Continued with previous interventions, heel cord stretches within WB restriction, closed kinetic chain hip/knee concentric exercises within WB restriction, soft tissue mobilization, NMES – Burst modulated AC (Russian) at maximum tolerable intensity, Game Ready Cold Compression.
Abbreviations: HEP, home exercise program; ROM, range of motion; NMES, neuromuscular electrical stimulation; AC, alternating current; WB, weight bearing	

with bilateral axillary crutches and total ROM brace locked at 0° extension without complications.

Following physician evaluation and physical therapy recertification, the patient was advanced to the controlled ambulation phase of the treatment protocol. During this phase, the patient was seen in the clinic 2 to 3 times per week for a total of 9 treatments. Physical therapy interventions (Table 4) included therapeutic exercises, manual therapy, and modality interventions to achieve full knee ROM, improve LE muscular strength and endurance, proprioception, balance, and neuromuscular control, restore confidence and function of movement, and progress gait to normal limits without WB restrictions, assistive device (AD) or total ROM brace. Between postoperative weeks 4 and 5, the patient was progressed to 50% WB in the total ROM brace locked at 0°extension with bilateral axillary crutches, and then progressed to 75% WB in the TROM brace locked at 0° extension and a single axillary crutch by the end of postoperative week 5. It was observed at this time that the patient ambulated with a vaulting gait pattern secondary to decreased right triceps surae extensibility.

As the patient progressed from the controlled ambulation phase and into the advanced activity phase, he was independently ambulating without AD or total ROM brace, had achieved 0° to 120° of tibiofemoral active ROM with increased strength and flexibility, had increased stability with anterior drawer testing, and was without pain. Impairments remaining included ROM, strength and flexibility deficits, impaired balance, decreased proprioception, and asymmetrical limb circumference.

During the advanced activity phase, the patient was seen in the clinic 2 times per week for a total of 15 treatments. Physical therapy interventions (Table 5) included therapeutic exercises, manual therapy, neuromuscular re-education, and modality interventions to achieve symmetrical strength, enhance muscular power and endurance, improve neuromuscular control, and progress to selected sport-specific drills. A physical therapy recertification was performed at the end of week 15 with assessment of knee circumference (Table 6). He exhibited 0° to 125° of active knee ROM and 5/5 muscular strength with MMT. Secondary to inability to detect strength deficits with MMT, the NeuroCom® system was used to assess functional strength during a lunge activity. The results demonstrated decreased force impact and time when compared to his non-involved LE indicating continued functional deficits. During his gait analysis, he was observed to have slight ankle pronation bilaterally at midstance, but otherwise gait was normal.

In the return to activity phase of treatment (Table 7), the patient was seen 2 times per week in the clinic for a total of 19 visits prior to discharge. During week 20 of the treatment protocol, a Lower Extremity Functional Scale (LEFS) was administered, with the patient scoring 71/80, rating his functional ability level at 89%. Limitations based on the

Table 4. Controlled Ambulation Treatment Protocol

Week	Interventions
4-5	Continued with previous interventions, passive and active lower extremity stretching, closed kinetic chain hip/knee/ankle concentric exercises within weight bearing restriction, Manual and instrument assisted soft tissue mobilization to lower extremity musculature.
5-6	Continued with previous interventions.
6-7	Continued with previous interventions, Stair climber, increased closed kinetic chain concentric exercises and progressed to single leg activities with full weight bearing.
7-8	Continued with previous interventions, Initiated single leg stance activity on non-compliant surfaces with/out dynamic upper extremity activity.

Table 5. Advanced Activity Treatment Protocol

Week	Interventions
8-9	Continued with previous interventions, elliptical, increased open kinetic chain and closed kinetic chain concentric exercises and progressed to single leg activities with full weigh bearing, initiated light intensity plyometric activity in gravity-eliminated positions.
9-10	Continued with previous interventions.
10-11	Continued with previous interventions. Initiated multi-directional movement training, slide board exercises, core stabilization exercises, progressed single leg stance activity to include compliant surfaces.
11-12	Continued with previous interventions.
12-13	Continued with previous interventions, progressed plyometrics to include gravity-resisted positions in sagittal and frontal planes.
13-14	Continued with previous interventions, progressed to dynamic lower extremity stretching exercises.
14-15	Continued with previous interventions, initiated Vertimax® training.
15-16	Continued with previous interventions, initiated light intensity linear running program on treadmill, and sport-specific activities without cutting/pivoting maneuvers.

LEFS included participation with usual hobbies, recreation, or sporting activities, squatting, getting out of a car, running on uneven ground, making sharp turns while running fast, and hopping. The patient exhibited 0° to 127° of active knee ROM. Isokinetic testing (speed 60°/s) was also performed during week 20, with the patient exhibiting peak torque LE hamstring to quadriceps ratio of 43% for the right LE and 57% for the left LE. Absolute peak torque deficit for the right LE was 11 foot-pounds for knee extension, and 33 foot-pounds for knee flexion. The patient exhibited knee extension peak torque-body mass ratio at a speed of 300°/s of 33% right LE, and 46% for the left LE. Continued NeuroCom®system functional strength assessments were completed during week 23 with continued force impact and time deficits. The LEFS was repeated at the start of week 27 with an increase in function to 91%. Based on the LEFS, continued limitations included running on uneven ground, making sharp turns while running fast, squatting, and participation with usual hobbies, recreation, or sporting activities. At week 28, prior to physician re-assessment, the patient completed his second isokinetic test (speed 60°/s), exhibiting a peak torque LE hamstring to quadriceps ratio increase bilaterally; 61% right LE and 72% left LE. Absolute peak torque deficit for the right LE was measured as 6 foot pounds for the knee extension and 20 foot-pounds for knee flexion. He exhibited a knee extension peak torque-body mass ratio at 180°/s of 66% right LE and 67% left LE, which was within the suggested return to sports range as reported by Myer et al.[13]

Following physician evaluation, the patient was allowed to begin cutting drills and an interval throwing program[17] (Table 8 and Table 9) with the possibility to return to sport within 3 weeks. As the patient desired to return to baseball pitching upon discharge, a throwing program was incorporated into physical therapy treatment episodes and in coordination with the high school pitching coach. Due to time restraints during treatments, only a portion of the throwing program was performed during treatment episodes to assess and monitor LE function and tolerance to activity.

Thirty weeks following surgical intervention, the patient returned to sport and was able to perform relief-pitching duties for his high school baseball team. By 3 weeks postoperative, he was pitching up to 4 innings without pain or limitations and was discharged from physical therapy care.

OUTCOMES

The patient presented to physical therapy one week following surgical intervention with significant ROM, muscular strength, and functional deficits resulting in activity limitations and participation restrictions requiring the need for skilled physical therapy. The patient exhibited excellent motivation and compliance throughout his rehabilitation process, which translated into significant ROM, muscular strength, and functional mobility increases.

As demonstrated in Table 1, the patient increased knee ROM from a limited 55° range, to a full 130°. Global strength of the knee, assessed via MMT, improved from 2/5 to 5/5. Isokinetic strength testing showed increases in peak torque hamstring to quadriceps ratio and decreases in absolute deficit in peak torque of the right LE compared to the unaffected left LE. The demonstrated knee extension peak torque-body mass ratio at 180°/s of 66% right LE and 67% left LE satisfied the return to sports criteria recommended by Myer et al.[13]

Tibiofemoral stability tests (Lachman's anterior and posterior drawer, varus and valgus stress) performed at discharge were negative. The patient self-reported 91% function based on his final LEFS administered 1 month prior to discharge. Secondary to the patient's knee function, strength, stability

Table 6. Knee Circumference Measures at Week 15

Circumference	Right LE	Left LE
5" above superior patella pole	55 cm	57 cm
2" above superior patella pole	48.5 cm	49 cm
1" above superior patella pole	47 cm	47 cm
Mid Patella	45.5 cm	45 cm
1" below inferior patella pole	44 cm	42 cm

Abbreviation: LE, lower extremity

Table 7. Return to Activity Treatment Protocol

Week	Interventions
16-17	Continued with previous interventions, progress running program intensity as tolerated.
17-27	Continued with previous interventions.
27-28	Continued with previous interventions, initiate cutting drills and throwing program.
28-31	Continued with previous interventions, dynamic running drills, sport-specific drills, return to sport.

Table 8. Return to Activity Phase Dynamic Running Program

Dynamic Phase	
50-yard run, 3 reps each of ½ and ¾ speed	100-yard run, 3 reps each of ½ and ¾ speed
Zig-Zag Run (round corners) 50 yards, 5 reps	Backward Run 25 yards then forward 25 yards 5 reps, gradual stops
Circle Run (20 ft. diameter) 3 reps to left/right	Figure 8 run (10 yards) 5 reps
Carioca (50 yard) 5 reps left/right	
Ballistic Phase	
Phase intensity: progress from walking to ½ speed to ¾ speed to full speed	
Run forward to plant and cut off of the non-involved limb, 5 reps	
Run forward to plant and cut off of the involved limb, 5 reps	
Zig-Zag drill with alternate limb plant and cut, 6 reps	
Box drill (20 yard) square, 6 reps alternate sides	
Shuttle run 50 yards with direction change every 10 yards, 5 reps	

Table 9. Return to Activity Phase Throwing Program

Warm-up	Warm–up Throwing 30-45 ft
Phase Progression	Initiate with Fast Balls Distance (ft.): 45, 60, 90, 120, 150, 180 Intensity: 50%, 75%, 100% Progress intensity at each distance prior to progressing distance
Number of Throws	25 throws followed by 5- to 10-minute rest intervals
Interval Throwing Program for Baseball Players[17]	

and isokinetic test results, he was released to return to sport participation at 7 months postoperative.

DISCUSSION

The purpose of this case report was to describe in detail the rehabilitation of a high school male athlete following ACL reconstruction with concomitant injuries to medial and lateral menisci, and the PLC of the knee. This case report demonstrates how progressive, multi-modal physical therapy interventions were employed to restore optimal lower extremity function following a complex traumatic contact sports injury and facilitate a safe return to sports participation. There is a significant amount of literature of isolated ACL tears with an expected return to sports participation generally at approximately 6 months.[1,5,10] However, the literature significantly lacks research detailing the rehabilitation of ACL reconstruction with concomitant meniscal and PLC injuries, although the same 6 to 9 month timeframe may be expected.[5,10-12] In general an agreed upon universal rehabilitation protocol for these patients does not exist.[10,13] The results of this case report indicate that a progressive, multi-modal physical therapy plan of care that uses objective return-to-sport criteria, such as isokinetic testing, allowed for the patient's return to sport within a 7-month timeframe.

A primary limitation of this case report included inconsistency in regular objective functional assessment over the course of treatment. For example, isokinetic test speeds used for testing ranged from 60-300°/s, with the only consistent speed across all sessions being 60°/s. Additionally, the LEFS was not employed until week 20 of physical therapy treatment. Greater consistency among isokinetic test speeds and earlier assessment of the LEFS would have allowed for more detailed assessment of the longitudinal functional progression of the patient.

In retrospect, addition of the Lower Extremity Functional Test (LEFT) would have provided the therapist even stronger evidence for return to sport in this patient. The LEFT assesses sport specific movement patterns with 8 agility drills consisting of forward run, backward run, side shuffle, carioca, figure 8 run, 45° cuts, and 90° cuts. Brumitt et al[18] demonstrated that an increased risk of thigh or knee injury is associated with LEFT completion times. Females who exhibited slower times were 6 times more likely to suffer knee and thigh injuries, whereas males who exhibited slower completion times had

increased risks of low back and lower extremity injury.

CLINICAL APPLICATIONS

Limited clinical evidence is available regarding rehabilitation of patients who have experienced concurrent ACL and PLC injuries and reconstruction, and no studies discuss such rehabilitation in detail. This case report described the detailed progress of a male athlete from beginning of rehabilitation to return to sport, and showed that a progressive, multi-modal plan of care that focused on objective assessment of knee performance to guide return to sport decisions allowed for successful rehabilitation outcomes.

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