Journal of Chiropractic Medicine (2012) **11**, 84–93

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JCM Journal of Chiropractic Medicine

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Multimodal and interdisciplinary management of an isolated partial tear of the posterior cruciate ligament: a case report

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Received 21 February 2011; received in revised form 14 September 2011; accepted 28 October 2011

Key indexing term:
Posterior cruciate ligament;
Manipulation, spinal;
Rehabilitation;
Muscle contraction;
Exercise therapy

Abstract

Objective: The purpose of this case report is to describe the evaluation and conservative management of an isolated posterior cruciate ligament (PCL) tear.

Clinical Features: A 32-year-old man with a traumatic right knee injury after tripping was initially diagnosed with medial patellar retinaculum tear at a multidisciplinary clinic. The patient received physiotherapy but reinjured the knee after returning to the sports field 3 weeks later. Subsequent clinical testing and magnetic resonance imaging confirmed a grade II isolated PCL tear.

Intervention and Outcome: Following the PCL tear diagnosis, a multimodal treatment approach over the course of 8 weeks consisting of chiropractic lumbopelvic manipulation, physiotherapy, and an exercise program emphasizing eccentric muscle action was implemented. Lunges, 1-leg squats, and trunk stabilization exercises were extensively used. Three months postinjury, the patient successfully returned to sports activity with no further complications.

Conclusion: The patient in this case report demonstrated successful return to preinjury functional status. This case highlights a multidisciplinary approach through the utilization of chiropractic, physiotherapy, and exercise therapies.

Introduction

Injury to the posterior cruciate ligament (PCL) is a common but often undetected injury among athletes. The incidence of PCL injuries varies from 3% to 44% of all acute knee injuries.[1] In clinical practice, PCL injuries are considered rare compared with anterior

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1556-3707/$ – see front matter © 2012 National University of Health Sciences.
doi:10.1016/j.jcm.2011.10.005

cruciate ligament (ACL) injuries.[2] Posterior cruciate ligament injury is regarded as one of functional disability, not functional instability as seen with ACL disruption.[3] Depending on the mechanism of injury, PCL tears can occur in isolation or in combination with other knee ligament structures, particularly the posterior lateral corner (PLC).

Presently, it is unclear which PCL-deficient knees will develop chronic symptoms and which will return to their preinjury level of activity without significant impairment.[4,5] Unlike the ACL and collateral ligaments, there is no general consensus on the treatment of isolated PCL injuries; nor is there a significant body of evidence to guide clinical management.[5] The literature suggests that knowledge and treatment of the PCL lag behind those of the ACL.[6] A review of the chiropractic literature reveals 1 citation describing 3 cases of isolated PCL injury.[7]

The purpose of this case report is to describe a multimodal, nonsurgical approach to the management of a PCL tear in a recreational tag rugby (oz tag) player. A combined treatment approach including chiropractic manipulation, physiotherapy, and exercise emphasizing single-leg eccentric muscle activity and core stabilization is presented.

Case report

A 32-year-old man reported right knee pain while playing tag rugby. While chasing an opponent, he tripped, impacting his right anterior knee onto the grass surface. He left the field unassisted but was unable to continue because of pain. Anteromedial swelling occurred that night, and ice was applied. Within 48 hours, the knee was examined at a multidisciplinary clinic, where a physiotherapist diagnosed a ruptured medial patellar retinaculum (a fibrous expansion of the vastus medialis tendon). At the time of consultation, there was no frank instability in ligament testing; and the patient reported 7/10 pain on the Numeric Pain Scale (NPS). Ultrasound imaging showed retinaculum damage and moderate edema. Physiotherapy focused on gentle thigh muscle soft tissue massage, flushing out edema, and restoring range of motion (ROM). Within 3 weeks, there was mild to no effusion. The patient was tested clinically with various 1-leg multidirectional hopping activities with no adverse effects and recorded an NPS of 0/10.

The patient returned to tag rugby; and within minutes, he experienced generalized right knee discomfort with twisting, cutting, accelerating, and decelerating activities. There was vague instability; and by half time, the knee had reswollen to the original injury level and 6/10 pain. Following examination, the physiotherapist was concerned about a meniscus (although the result of the McMurray test was inconclusive) or a partial cruciate ligament injury (although the results of the Lachman test and the posterior drawer test were difficult to qualify because of swelling). The physiotherapist referred the patient to a knee orthopedic surgeon, who on physical examination noted pain on active and passive knee flexion. Because of swelling, right knee flexion ROM was limited to approximately 100°. Full active and passive knee extension was painless. Deep squat and kneeling reproduced right, deep knee pain "throughout" the knee. Mild tenderness to palpation was noted over the medial femoral condyle, whereas popliteal fossa and medial joint line palpation was unremarkable. Medial gastrocsoleus and vastus medialis obliquus muscle atrophy was noted. A palpable step off was absent from the tibial plateau at 90° flexion. The posterior sag sign was negative, but a positive posterior drawer test result of approximately 8- to 10-mm laxity (with a soft end feel) raised suspicion of a grade II tear of the PCL. The result of the posterior drawer test with maximal external rotation was negative, and the reverse pivot shift test was difficult to perform because of patient guarding. Meniscal and other knee ligamentous structures were intact. Anterior drawer and Lachman test showed laxity with a soft end feel compared with the left knee. A clinical diagnosis of a PCL tear was made, with the possibility of ACL damage as well. Subsequent magnetic resonance imaging (MRI) revealed a high-grade midsubstance tear of the right PCL, confirming the clinical diagnosis (Fig 1). Also reported were moderate joint effusion and proximal, anterior medial tibial bone contusion. The right ACL appeared intact. Radiographs showed no signs of fracture, bone avulsion, or other pathology. Alignment views were normal.

Nonsurgical management was suggested with a review in 8 weeks. Therapy included quadriceps strengthening, hamstring stretching, and balance (proprioception) exercises. A knee brace was not recommended. Treatment initially consisted of various soft tissue release techniques and dry needling to the gastrocsoleus, rectus femoris, and vastus medialis oblique, aiming to reduce muscle tone and edema. Chiropractic assessment and manipulation to dysfunctional lumbopelvic joints were applied to restore joint mobility and proprioceptive integrity. Manipulation was performed once a week for a month and

Fig 1. Magnetic resonance imaging. Clear arrow shows high-grade midsubstance tear of the right PCL.

then as required the following month, depending on chiropractic examination.

Rehabilitation exercises initially consisted of double-leg squats, static hamstring stretches, and single-leg balance exercises. However, given the dynamic nature of tag rugby (repeated acceleration, deceleration, and change of direction) along with the patient's desire to continue various dry-land– and aquatic-based activities such as water polo and surf lifesaving, more dynamic exercises were recommended. Self myofascial release techniques across all hip musculature were encouraged several times a week using a foam roller. Initially, quadriceps training progress was slow. The patient struggled with excessive knee valgosity and impaired 1-leg balance during partial lunges and 1-leg 1/4 squats. X band training (a weight-bearing exercise for the hip external rotators and abductors, moving in the frontal plane against a resistance band) was prescribed to help minimize knee valgosity (Fig 2). As effusion dissipated, rehabilitation focused on increasing ROM in eccentric hip and knee exercises. This included 3 sets of 8 repetitions for 1-leg and split squats and 3 sets of 30 seconds for the quasi-eccentric isometric holds (Figs 3 and 4). Proprioception exercises were performed in the

Fig 2. X band walking—frontal plane stimulus for the hip external rotators and abductors. Patient steps out laterally. Note: externally rotated feet.

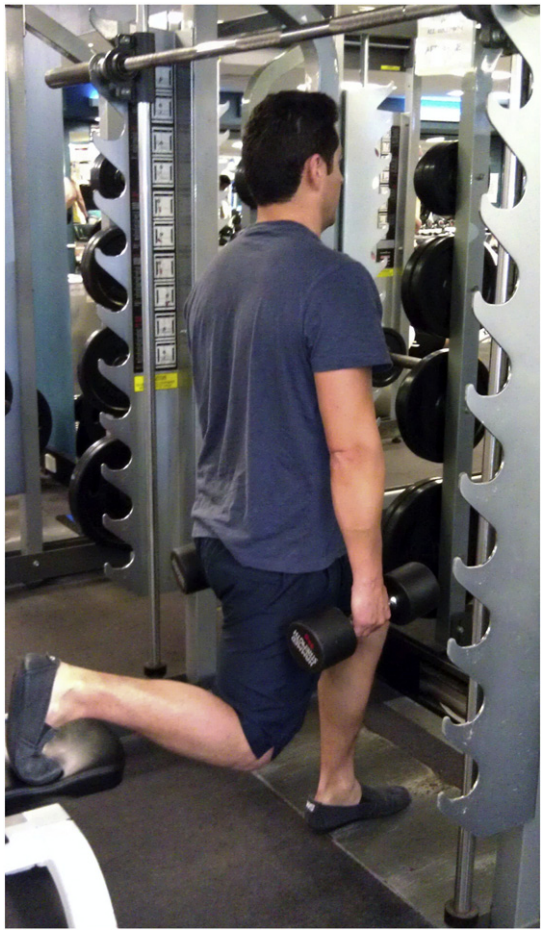

Fig 3. Quasi-eccentric isometrics holds—rear foot elevated in split squat stance. Exercise begins as an isometric contraction in a partial lunge position.

Fig 4. Quasi-eccentric isometric holds—as fatigue sets in, the trunk slowly lowers toward the ground, creating a slow eccentric contraction; activating gluteus medius and maximus, along with the thigh muscles. Note: the trailing leg hip flexor and quadriceps receive a strong stretch.

single-leg stance. All exercises were repeated 3 times a week, at least once a day, and also included isometric core (spinal) stability exercises on a stable surface (3 sets of 30-second holds). During weeks 4 to 8, pain was 0/10 on the NPS; and improvement in exercise control and ROM was noted. Table 1 presents the time line for therapies and exercises used during PCL rehabilitation.

Eight-week orthopedic review showed impressive recovery. Posterior drawer test showed a hard end feel for the right PCL; and there was a palpable step off of 0.5 cm at 90° of knee flexion, an improvement attributed to increased quadriceps strength and natural healing of the PCL. Knee flexion ROM was pain free and improved to approximately 140°. Despite minor medial quadriceps muscle atrophy, the patient successfully returned to tag rugby exactly 12 weeks following the initial injury. No further problems have been experienced 3 years postinjury.

Discussion

There is controversy regarding the treatment of PCL injuries.[8] Posterior cruciate ligament injuries are subtle and easily missed on physical examination. Furthermore, PCL anatomy, mechanism of injury, physical examination procedures, diagnostic imaging, healing capacity, and debate surrounding its natural history all provide a number of challenges for the treating practitioner. Quadriceps muscle strengthening is a mainstay of therapy, but there is no consensus with entire PCL rehabilitation. This case report provides an integrated and conservative treatment approach, which may encourage positive collaboration and referrals with other allied health care professionals.

Anatomy

The PCL is thicker, shorter, and almost twice as strong as the ACL,[9] predisposing avulsions of the bony tibial attachment rather than ligament rupture. The PCL is a major stabilizer of the knee, with an average length between 32 and 38 mm.[10] Anatomically, it consists of 2 bundles: the larger anterolateral (AL) bundle, which tightens in flexion, and the smaller posteromedial (PM) bundle, which tightens in knee extension. The AL bundle is double the cross-sectional area of the PM bundle.[10] Biomechanically, the AL and PM components of the PCL act as a primary restraint to posterior tibial translation and a secondary restraint to external tibial rotation.[4,11] The collateral ligaments and the PLC act as secondary restraints. The meniscofemoral

Table 1 Treatment protocol weeks 1 to 8 post orthopedic consultation (passive and active modalities)

	Weeks 1-2	Weeks 2-4	Weeks 4-6	Weeks 6-8
Spinal manipulation	*	*	*	
Soft tissue therapy	*	*	*	
Foam rolling	*	*	*	*
Static stretching: hamstring	*	*		
2-Leg squats	*			
1-Leg balance	*			
X band walking		*	*	
Partial forward and reverse lunges		*	*	
1-Leg squats		*	*	*
Eccentric isometric holds			*	*
Split squats			*	*
Spinal stability	*	*	*	*

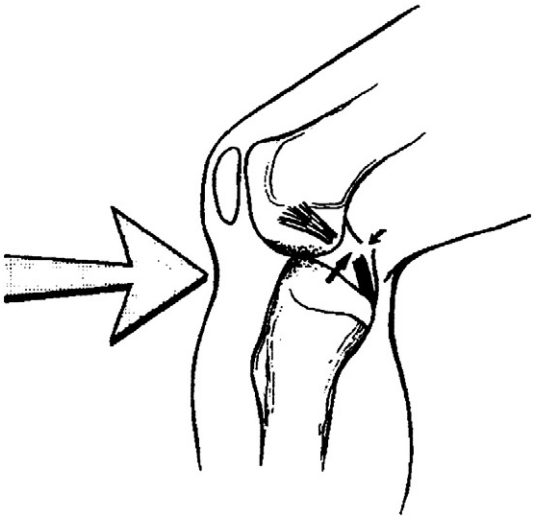

Fig 5. Forceful posterior displacement (white arrow) of the tibia relative to the femur in the flexed knee usually results in a midsubstance PCL disruption (black arrow). (Reprinted with permission from Sonin AH, Fitzgerald SW, Friedman H, et al. Posterior cruciate ligament injury: MR imaging diagnosis and patterns of injury. Radiology 1994;190(2):455-58.)

ligaments (ligaments of Humphrey and Wrisberg) obliquely cross the posterior aspect of the PCL.[10] At 90° of knee flexion, the meniscofemoral ligaments provide approximately 28% of the total force resisting posterior tibial translation.[11]

Mechanism of injury and clinical evaluation

Injury to the PCL typically results from either of 3 mechanisms: (1) knee hyper extension, (2) knee hyper flexion, and (3) the classic "dashboard injury" in motor vehicle accidents where the proximal tibia receives an anterior to posterior directed blow to the flexed knee (Fig 5). Another common injury mechanism is when the athlete falls onto a flexed knee with the foot in plantar flexion, the proximal tibia striking the ground first.[5] Unlike patients with isolated ACL tears, those with acute isolated PCL injuries do not typically report feeling or hearing a "pop."[12] An isolated PCL injury does not usually cause specific symptomatic complaints,[10] with knee pain, swelling, and stiffness often mild in severity.[12] Localized pain is common in acute injuries, especially on kneeling or decelerating.[13] Instability (giving way) is a key symptom in isolated PCL-deficient knees, particularly during stair descent.[14] Such clues would aid the diagnosis of a PCL injury due to subtlety of symptoms and clinical findings.[15]

Physical examination maneuvers

The most accurate clinical test for detecting PCL injury is the posterior drawer test,[10,16] with a reported sensitivity of 90% and specificity of 99%.[5] It is essential to note the change in distance of step off between the medial tibial plateau and the medial femoral condyle (Fig 6). Normally, the plateau is approximately 1 cm anterior to the tibial condyle with the knee flexed at 90°.[4] A comparison to the noninjured knee is vital.[12] In grade I injuries, the tibia remains anterior to the femoral condyles; but the distance is diminished (0-5 mm). In grade II, the tibia is even or level with the femoral condyles, but not posterior to the condyle (5-10 mm). With a grade III tear, the tibial no longer has a medial step off and can be pushed beyond the medial femoral condyle (>10 mm). Grade III injuries indicate a complete tear and are often combined injuries, implicating the PLC.[6,12] Other PCL tests include the

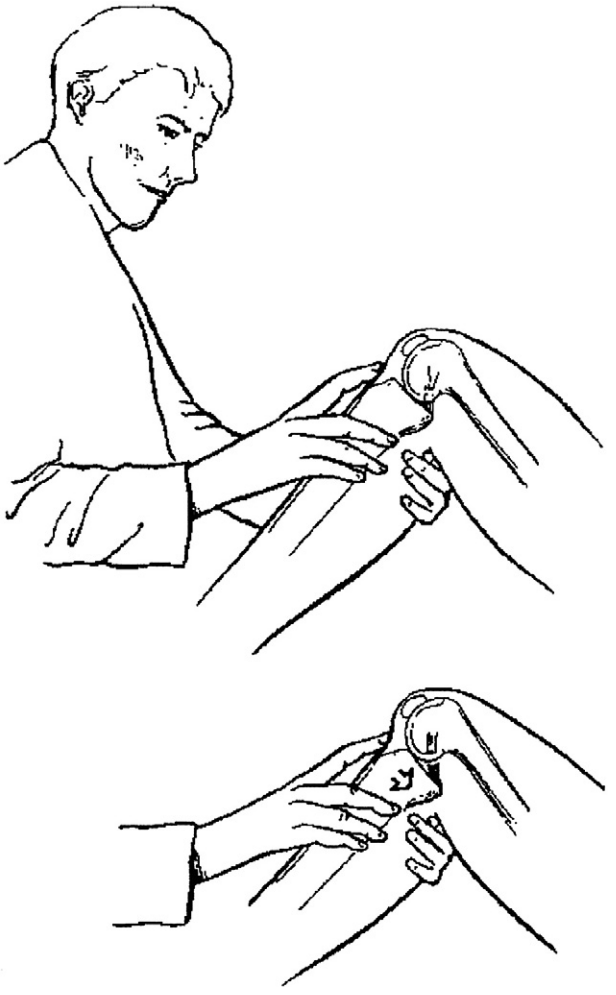

Fig 6. Posterior drawer test (note the palpable step off). (Reprinted with permission from Annunziata et al.[12])

posterior sag sign (79%, sensitivity; 100%, specificity) and quadriceps active test (54%, sensitivity; 97%, specificity).[5] The reverse pivot shift test (26%, sensitivity; 95%, specificity) is also useful in ruling out a combined PCL injury.[4] Proper evaluation of the PCL is not complete without evaluation of other ligament structures.[12] Table 2 describes commonly used tests for posterior and posterolateral instability.

Special care must be taken in evaluating the ACL in the presence of PCL insufficiency. The noninvolved knee must be examined first to determine the normal relationship of tibia to the femur because, in the PCL-injured knee, the tibia will be subluxed posteriorly. Once corrected in the injured knee, standard anterior drawer and Lachman tests can be performed.[12] If anterior drawer is performed from a back drawn position, it may appear to show excessive anterior laxity, producing a false-positive result.[9]

Natural history of PCL injury

Controversy exists concerning the most appropriate treatment of isolated PCL injury.[15] The long-term effectiveness of nonoperative treatment is unknown. This is largely due to the absence of randomized trials comparing treatment outcomes and few prospective studies outlining the true natural history of PCL injury.[5]

Numerous authors note satisfactory to good short-term outcomes with nonsurgical management of isolated PCL tears. Parolie and Bergfield[17] found that 80% of patients that had greater than 100% strength of the uninvolved quadriceps were satisfied with their PCL-deficient knees. Fowler and Messieh[18] observed that all patients return to their previous activity, experiencing no limitations with their PCL injured knee, with good subjective and functional ratings. Shelbourne and Muthukaruppan[19] concluded that 80% of PCL ruptures can have good to excellent results with effective nonoperative management. Their subjective scores were independent of laxity and did not deteriorate over time. Fontbote et al[20] assessed gait and a 30-cm 1-legged vertical drop on chronic grade II PCLs. Four years postinjury, there was no significant difference with strength testing or muscle group activity, leading to the conclusion that PCL-deficient knees may not have symptoms of instability. Furthermore, Torg et al[21] found that degenerative joint disease will not develop secondary to the injury if isolated to the PCL only. Even in the presence of articular damage, isolated PCL may be successfully managed with conservative treatment.[22] Depending on the severity of PCL injury, returning to sports activity may take between 1 to 3 months postinjury.[23] Toritsuka et al[24] found that a return to sports activity may range between 1 and 7 months postinjury.

Other authors have observed long-term complications from PCL injuries. Allen and Kaplan[25] found that chronic PCL insufficiency may result in patellofemoral and medial compartment degenerative arthritis. Clancy et al[26] discovered moderate to severe articular injury of the medial femoral condyle during surgery in 48% of the patients with chronic PCL injury. These degenerative changes increase proportionately to the length of time after injury in the PCL-deficient knee. The incidence of articular defects and meniscal tears increased in chronic PCL injuries, mostly in the medial compartment.[27] Other authors document radiological evidence of degenerative changes gradually increasing after the time of injury,[28] particularly in the presence of abnormal/symptomatic posterior laxity.[29] Overall, studies appear to show satisfactory short-term results and controversial long-term outcomes associated with isolated PCL injury.

Table 2 Physical examination tests for posterior and posterolateral instability

Posterior drawer	Knee is flexed to 90°; posteriorly directed force is applied to proximal tibia
Posterior sag	Ipsilateral hip and knee are flexed to 90°; observe the knee from a lateral position for abnormal contour or sag at proximal anterior tibia
Quadriceps	Knee is flexed to 90°; patient either contracts quadriceps muscle or active test slides foot down table. Observe for tibia translating anteriorly from a posteriorly subluxed position.
Reverse pivot shift	With leg externally rotated, valgus stress is applied to knee while it is extended from 70° to 80° of flexion. Test result is positive when tibia reduces at approximately 20° of flexion.
Dial test	External rotation of legs is compared with the knee at 30° and 90° of flexion.

Reprinted with permission from Clovin AC, Meislin RJ: Posterior cruciate ligament injuries in the athlete: diagnosis and treatment. Bull Hosp Jt Dis 2009;67(1)45-51.

Diagnostic imaging

Radiographs are often requested to detect small tibial plateau fractures.[16] They may also demonstrate posterior tibial sag or avulsion fractures on the lateral view.[5] The extent of posterior displacement may be altered if the patient is guarding the knee through quadriceps activation.[11] Magnetic resonance imaging is the criterion standard for evaluating PCL injuries, with accuracy ranging from 96% to 100%.[6] It will also

identify associated injuries including bone bruising,[13] which may be evident in the medial and lateral compartments.[5] Magnetic resonance imaging can also be used as a follow-up to PCL injuries. Tewes et al[30] reexamined patients with PCL insufficiency between 4 months to 5 years postinjury. In 77% of the cases, the PCL appeared hyperbuckled but continuous from the tibia to femur. The remaining 23% were discontinuous. The MRI interpretation indicated that healing had taken place, yet all were clinically examined and judged to have PCL insufficiency. Magnetic resonance imaging appears to be reliable from an evaluation standpoint, but not so regarding functional status.[30] Others note the PCL may regain a normal MRI appearance after initial injury.[5] Shelbourne and Gray[31] found that all partial tears had healed, 86% had regained continuity, but the PCL did not heal back to normal configuration.

Nonsurgical management

The premise behind most PCL treatment strategies revolves around quadriceps strengthening. Achieving 100% quadriceps strength when compared bilaterally is recommended.[9] This may minimize posterior tibial translation and reduce patellofemoral irritation.[9] Interaction of segments above and below the knee, particularly pelvic, hip, and ankle mechanics, must be considered in PCL rehabilitation. Treatment protocols in this case report favor a functional, multidisciplinary approach to lower extremity kinematics.

Lumbopelvic manipulation

Knee joint pathologies are generally associated with a loss of knee extensor muscle strength.[32] *Lumbopelvic manipulation*, defined as a high-velocity, low-amplitude thrust directed to a synovial joint with the purpose of restoring normal articular function,[33] was used for the reduction of quadriceps muscle inhibition in the knee. Spinal manipulation is theorized to impact primary afferent neurons from paraspinal tissues, the motor control system, and pain processing.[34] The neurophysiologic changes associated with manipulation may be of benefit through sensory receptor stimulation (large myelinated fibers) in and around the joint affecting the central nervous system at the spinal segmental level,[35] resulting in intense capsular and/or periarticular tissue stimulation. The sacroiliac joint (L2-S3), quadriceps (L2-4), and knee joints (L2-S2) all share common nerve root levels.[35] This familiarity, along with the rich innervations of the sacroiliac joint,[36] may allow afferent stimulation from one structure affect the efferent response to structures innervated by similar nerve roots. Pelvic and hip musculature may therefore experience reflexive facilitation following manipulative therapy.[34]

Furthermore, quadriceps changes following lumbopelvic manipulation have been observed, with an increased quadriceps force output and immediate muscle activation in both healthy and symptomatic subjects.[35] Afferent input to the spinal cord from joint receptors appears to be an influential factor in the neurophysiologic response associated with force output and activation. Thus, atrophy, decreased cross-sectional area, and strength losses could be minimized through this proposed lumbopelvic manipulative effect,[32] making it a useful addition to PCL rehabilitation.

Eccentric muscle training

The gluteal muscle group, hamstrings, and quadriceps muscles play an integral role in those suffering from complications associated with isolated PCL insufficiency. MacLean et al[37] found eccentric strength deficiency in the quadriceps of both extremities and the hamstrings of the injured extremity in athletes conservatively treated for isolated PCL injury. Difficulty with stair descent, sudden changes in direction, and squatting were common complaints in this group. Shirakura et al[38] noted a significant decrease in quadriceps eccentric and concentric torque in PCL-injured limb. Furthermore, weakness in eccentric hip abduction and hip external rotation allows increased hip adduction and internal rotation during functional movements.[39] Thus, eccentric muscle training of surrounding hip and knee musculature may be necessary to prevent injury.[40]

Slow eccentric contractions (eccentric quasi isometrics) can be executed progressively throughout full joint ROM. Relevant for maximum strength, hypertrophy, and active flexibility,[41] eccentric training can enhance faster initial adaptation to strength training when compared with similar concentric loading.[42] Comparable findings have also been noted with muscle hypertrophy.[43] Flexibility and length-tension relationships can also be restored, as strength training promotes additional sarcomeres in parallel (increased muscle cross-sectional area) and in series (increased muscle length). Muscles trained eccentrically could induce structure adaptations through increased sarcomeres in series, allowing muscle length increases.[44] Another benefit of eccentric training is an increase in muscle stiffness, which improves the viscoelastic muscle-tendon unit's absorption and utilization of elastic

energy, thereby providing resistance to potential disruption and enhancing injury prevention.[45]

Single-leg training and proprioception

Along with limiting anterior-posterior knee translation, the PCL also checks medial-lateral translation and rotation of the knee during weight-bearing knee flexion.[46] Weight-bearing, single-leg exercises may activate appropriate knee stabilizers and minimize the potential long-term degenerative changes seen in PCL-deficient knees. Partial 1-leg squats and various lunges (up to 45° knee flexion) were first encouraged because they minimized patellofemoral cartilage contact.[47] The single-leg squat can stimulate thigh and buttock muscle groups,[48,49] challenging them through all planes of motion in preparation for future sport-specific challenges such as landing, decelerating, and changing direction. One advantage with single-leg training is that it can decrease the potential influence of leg dominance on injury risk.[49] Proprioceptive deficits were also adequately addressed with single-leg exercises, as balancing on one leg creates antagonist coactivation,[49] enhancing knee joint protection. Proprioceptive shortfalls may inhibit protective reflexes and muscle activity, contributing to degenerative changes in PCL-deficient knees.[1]

Core stability training

The body core (trunk) stabilizers consist of the passive thoracolumbar spine and pelvis and active trunk musculature.[50] Knee stability depends on accurate sensory input and appropriate motor responses to meet the demands of rapid changes in trunk position including cutting, stopping, and landing movements.[51] Core stability is the foundation of trunk control, allowing production, transfer, and control of force (and motion) to distal segments of the kinetic chain. Neuromuscular deficits in the core allow uncontrolled trunk displacements throughout athletic activities, potentially placing the lower extremity in a valgus position, putting the knee under ligamentous strain.[51] Altered trunk muscle activation, excessive hip adduction and internal rotation, and knee valgus during gait or other orthopedic assessments[52] indicate that core stabilization in knee rehabilitation is warranted. Isometric, endurance-based core exercises in multiple planes known as the *Big 3* were prescribed on a stable surface in this case report. The reader is encouraged to read the work of McGill[53] for the core exercise progressions used in this case.

Limitations

As a single case report, limitations include the possibility of spontaneous recovery due to the extrasynovial component of the PCL.[54] In addition, it cannot be assumed that this multimodal approach is superior to any other form of conservative PCL rehabilitation. Furthermore, rigorous outcome measures were lacking in this report. Future studies should look to determine the effects of chiropractic manipulation and how it can fit into existing rehabilitation protocols, particularly regarding extremity functional restoration. In addition, long-term follow-up and/or imaging (ie, yearly) may assist in documenting future degenerative changes associated with isolated PCL injury.

Conclusion

The patient in this case report demonstrated successful return to preinjury functional status. This case highlights a multidisciplinary approach through the utilization of chiropractic, physiotherapy, and exercise therapies. Isolated PCL injuries are less common than other knee injuries, resulting in a lack of evidence-based literature regarding their treatment. Whereas some will return to normal function, others may be left with a variety of symptoms and disability. The predictive factors that may determine which patients will develop knee pain and degenerative arthritis have yet to be identified. Because of the subtleness and effects of isolated PCL injuries, emphasis is placed on a meticulous history and physical examination. Coupled with appropriate imaging studies and an interdisciplinary treatment approach, PCL preinjury functional status may be achieved.

Acknowledgment

The authors thank Dr Darren Chen for reviewing an earlier draft of this paper.

Funding sources and potential conflicts of interest

No funding sources or conflicts of interest were reported for this study.

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