Management And Treatment Of Injuries To The Posterolateral Corner Of The Knee

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***Abstract*—The postero-lateral corner (PLC) of the knee is changing its perception from "dark-side of the knee" due to the amount of literature being produced on the topic. The PLC is made of various dynamic and static stabilizers, the primary restraints being: The fibular collateral ligament (FCL), popliteo-fibular ligament (PFL), and popliteal tendon. Injuries to the PCL can either occur in trauma or athletic competition and usually occur concomitantly with the cruciate ligaments of the knee. There are variety tests with good diagnostic value but the gold standard in diagnosing PLC injuries is still the MRI. Grade 1 and 2 injuries can be managed with exercise therapy while grade 3 injuries are managed with surgery. The purpose of this article is 2- fold: to present an overview of PLC injuries, including common diagnostic strategies and management techniques. This article will give clinicians specific rehabilitation concepts and strategies for application which is an area that is vastly unresearched and the authors of this paper seek to change.**

Introduction

The posterolateral corner has been ominously labeled the "dark side of the knee" due to lack of literature and information on the topic (Cooper et al., 2006; James, LaPrade, et al., 2015). Furthermore, educational curriculums emphasize the importance of knee stability from a ligamentous (MCL, LCL) and cruciate (ACL, PCL) standpoint ((Pritchard et al., 2016; Snyder-Mackler, 2001; Williams et al., 2001). Although these structures do provide stability to the knee, the concept of rotational and multidirectional is becoming more relevant (Crespo et al., 2015; Pacheco et al., 2011). In sport, concurrent injuries are common such as cruciate ligament and meniscus and may lead to instability and laxity beyond only the sagittal or frontal plane (Barber, 1992; Sakryd & Martindale, 2020; Shelbourne & Nitz, 1991). The posterolateral corner (PLC) of the knee consists of a combination of 8 static and dynamic structures of which the popliteal tendon, fibular collateral ligament, and popliteo-fibular ligament provide the most support (Geeslin et al., 2016; Moulton et al., 2016; Sekiya et al., 2010). The PLC's main function is to resist vectors in the postero-lateral direction (Chahla et al., 2016a; Moorman & LaPrade, 2005; Vinson et al., 2008). Due to its function, the PLC has an intricate relationship with both the ACL and PCL (Dean & LaPrade, 2020; Temponi et al., 2017a). Combined injuries to the PLC with either ACL or PCL are more common than isolated PLC injuries (Bonanzinga et al., 2015; Fanelli et al., 2009; Hassebrock et al., 2020). An injury to the PLC can have negative consequences on activities of daily living and athletic performance due to increased joint degeneration and lack of knee stability (Schweller & Ward, 2015; Shon et al., 2017a). There is a multitude of research on how to address injuries to the cruciate ligaments and menisci in terms of surgical and exercise therapy interventions (Boden et al., 2010; Ryder et al., 1997; Yu & Garrett, 2007). In sport, the ultimate goal is return to performance and being able to have an optimal rehabilitation program is an important part of this process (Buckthorpe et al., 2019a; Ryder et al., 1997). Multiple papers have been written highlighting the diagnosis, management, and rehabilitation of cruciate injuries, ligamentous injuries, and meniscal injuries (Erickson et al., 2014; Paterno et al., 2018; Thomeé et al., 2011). Within the PLC field, there is growing research into diagnostics (both clinical and imaging) along with superior surgical techniques aimed at restoring knee stability (Cooper et al., 2006; Pacheco et al., 2011; Petrillo et al., 2017; Williams et al., 2001). However, practical rehabilitation techniques for treating clinicians have not been explored to the knowledge of the authors. The purpose of this systematic review is to lay the foundation of the most current evidence as to the diagnosis, management, and rehabilitation of PLC injuries.

Materials and Methods

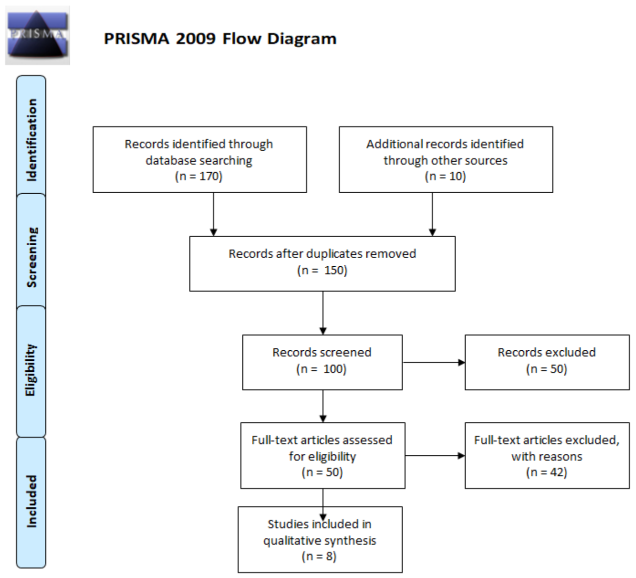
We performed a systematic review of the literature according to the PRISMA guidelines with a PRISMA checklist (Fig. 1) and flow diagram (Fig. 2). Two independent reviewers (B.S. and L.T.) conducted the search separately. The search was performed on January 1, 2021. The following databases were screened: Medline, Cochrane, EMBASE, Google Scholar and Ovid. Only articles in English were included. The key words used for the search were 'posterior cruciate ligament' or 'PCL' with 'posterolateral corner' or 'PLC' and 'chronic'; 'injury'; 'management'; 'reconstruction'; 'outcomes'; 'complications'.

Inclusion and exclusion criteria are listed in Table 1. Only articles published in peer review journals were considered. Articles were initially evaluated by title and abstract. Full-text articles were obtained if the abstract did not allow the investigators to assess whether a given article could definitely be included or excluded at this stage. Each abstract and article was reviewed by two investigators separately, and a cross-reference search of the selected articles was performed to identify other relevant studies.

All articles reporting preoperative and post-operative clinical outcomes, as well as treatment, management, and rehabilitation on PLC injuries were included.

Statistical Analysis

All the statistical evaluations were performed using Microsoft Excel (Microsoft; Redmond-Washington) and SPSS for Mac (IBM SPSS Statistics Desktop version 22.0; Chicago-Illinois). The comparison between preoperative and postoperative clinical scores was performed using the Wilcoxon–Mann–Whitney test. P values lower than 0.05 were considered statistically significant. The categorical variables were reported as frequency with percentage. Continuous variables data were reported as mean ± standard deviation and range as minimum and maximum values. In all studies, P values less than 0.5 were considered statistically significant.



Results

A total of 180 records were identified through data base searching. After duplicates were removed and records screened for relevant information, 8 articles eligible for the present systematic review.

Anatomy and Function of the PLC

The PLC is comprised of both static and dynamic stabilizers, the static stabilizers include the fibular collateral ligament (FCL), popliteus tendon, popliteofibular ligament, lateral capsule thickening, arcuate ligament, and fabellofibular ligament (Bowman & Sekiya, 2010; Dold et al., 2017b; James, Laprade, et al., 2015). The dynamic stabilizers include the biceps femoris, popliteus muscle, iliotibial (IT) band, and lateral head of the gastrocnemius (Crespo et al., 2015; *RECOVERY AFTER POSTEROLATERAL CORNER AND POSTERIOR CRUCIATE LIGAMENT INJURY.: Big Search*, n.d.; Rosas, 2016; Shon et al., 2017a). Of these structures, the primary stabilizers of the PLC are the FCL, popliteus tendon, and popliteofibular ligament (James, LaPrade, et al., 2015; Petrillo et al., 2017; *Role of the Popliteal Fossa in Knee Problems: Theoretical Considerations and Practical Implications | Journal of Modern Rehabilitation*, n.d.). The PLC works to resist varus forces and hyperextension to the knee while resisting external rotation and posterior translation of the tibia (Bowman & Sekiya, 2010; James, Laprade, et al., 2015). Due to the synergistic nature of the PLC with the cruciate ligaments, up to 72% of all PLC injuries are combined with the PCL or ACL.

Presentation and Diagnosis of PLC injuries

Injuries to the PLC occur most commonly when through a hyperextension injury (contact or non-contact), direct trauma to anteromedial knee, or varus forces to the knee ((Gwathmey et al., 2012a; Shon et al., 2017b). Clinically, patients will present with pain and instability at the postero-lateral aspect of the joint. Due to proximity of the common fibular nerve, neurological symptoms of the ankle dorsiflexors and great toe extensors may be present (Ridley et al., 2018). Patients will often report difficulty with twisting, turning, and pivoting and pain along the outside of the knee (Chahla et al., 2016b; Dold et al., 2017a). There are many tests used to diagnose PLC injuries including the varus stress test, dial test, posterolateral drawer test, external rotation recurvatum test, and reverse pivot shift test ((Chahla et al., 2019a; Skendzel et al., 2012; Strauss et al., 2007). Of these tests, the most clinically accurate tests are Dial test at both 30 and 90 degrees, posterolateral drawer test, and reverse pivot shift test (Petrillo et al., 2017; Shon et al., 2017a). In chronic injuries, patients may have a varus thrust gait which may increase compressive forces on the medial compartment and lead to accelerated osteoarthritis. Radiographs are performed as the first imagine and may include a normal 2-view of the knee and may reveal an avulsion fracture of the fibular head or femoral condyle (Hash, 2013; Temponi et al., 2017a). Stress radiographs may be taken to assess lateral joint gapping for integrity of the FCL and PLC (Gwathmey et al., 2012b). In chronic injuries, long-leg standing radiographs are taken to assess varus alignment in the injured knee. The MRI is considered to be the most sensitive imaging modality in diagnosing a PCL injury (Bolog & Hodler, 2007; Hash, 2013). The MRI allows the clinician to look for injuries to the LCL, popliteus, and biceps tendon (Bolog & Hodler, 2007; Hash, 2013). In acute injury, bone bruising may be seen on the medial femoral condyle and medial tibial plateau (Geeslin & Laprade, 2010). The clinician should be sure to order a coronal oblique thin-slice through the fibular head as this is best for visualizing the structures of the PLC.

Management of PLC injuries

In the literature, PLC injuries are most commonly classified according to the Hughston and Fannelli which was then modified into the Modified Hughston Classification (Baker et al., 1983; Hughston & Norwood, 1980; Lunden et al., 2010). The modified hughston classification uses 3 clinical components along with 3 grades of injury. The clinical components include: Varus stress lateral opening at 30 degrees of knee flexion, rotational instability on dial test, and posterolateral drawer test. Injuries can be graded 1 (Mild), 2 (Moderate), or 3 (Severe) depending on the amount of joint gapping and translational compared to the uninjured side (Baker et al., 1983; Hughston & Norwood, 1980; Lunden et al., 2010). There is good evidence to support managing grade 1 and 2 injuries with exercise therapy with good-excellent outcomes(Bonanzinga et al., 2015; Dean & LaPrade, 2020; Skendzel et al., 2012). Grade 3 injuries are managed with surgery due to the large amount of rotational instability in the knee. There are two main types of surgical intervention: repair and reconstruction (Levy et al., 2010; Stannard, Brown, Farris, et al., 2005; Vermeijden et al., 2020). Surgical repair is possible when the injury is diagnosed early and performed within 1-2 weeks after it occurs (Vermeijden et al., 2020). Since this injury goes undiagnosed or misdiagnosed, surgery occurs after this time period and surgical reconstruction is necessary. Within reconstruction, two techniques are most popular: anatomic and non-anatomic. The anatomic techniques seek to restore the native function of the FCL, PFL, or Popliteal tendon and has better patient reported outcomes vs the non-anatomic techniques (Jakobsen et al., 2010; Stannard, Brown, Robinson, et al., 2005).

Post-Operative Rehabilitation

The post-operative rehabilitation of isolated or combined PLC injuries is the area lacking the research. PLC injuries treated with exercise therapy are stabilized in a hinged brace permitting full range of motion for 2-4 weeks followed by a progressive rehabilitation program with an emphasis on quadriceps strength (Chahla et al., 2019b; Lynch et al., 2017). Other studies have proposed the knee to be initially protected with a long lever brace and limited weight bearing to encourage healing (Chahla et al., 2016c). For non-operative management, most studies advocate for knee immobilization for 4 weeks followed by a progressive functional rehabilitation focusing on quadriceps strength and a return to sport in about 8 weeks (Chahla et al., 2016b; Dold et al., 2017a). Operative rehabilitation of PLC injuries (repair) are found to be managed with a hinged knee brace, non-weight bearing status for 6 weeks (Edson, 2003; Fanelli, 2008; Fanelli et al., 1996). Range of recommendations range from 0-90 degree PROM to strict immobilization 2 weeks post-op (Crespo et al., 2015; Shon et al., 2017a; Welsh et al., 2016). However, at 6 weeks full weightbearing commences along with progressive strengthening (Chahla et al., 2019a; Lunden et al., 2010). Return to sport may begin at starting at 6 months (Fanelli, 2008; Franciozi et al., 2019; Koong et al., 2018). PLC reconstruction differs slightly in that post-operative immobilization lasts for 4 weeks with PROM being performed during this time period to reduce risk of arthrofibrosis. Active strengthening of the hamstrings is avoided to reduce stress on the fresh PLC reconstruction (Franciozi et al., 2019).

Discussion

Injuries to the PLC are deemed rare because they either go undiagnosed or misdiagnosed. In ACL and PCL reconstructions, untreated PLC injuries are a common source of failed surgery and low patient reported outcomes (Dhillon et al., 2012; Temponi et al., 2017b). Injuries to the PLC occur in athletic and non-athletic activities with contact or non-contact mechanisms. The most common injuries are seen in athletic events with contact to the anteromedial knee which results in hyperextension and postero-lateral gapping of the knee which injures the PLC and possibly the ACL/PCL (Baker et al., 1983; Lunden et al., 2010). The primary stabilizers of the PLC are the FCL, PFL, and popliteus tendon (Chahla et al., 2019a; Skendzel et al., 2012). The clinical exam is crucial, especially implementing a thorough history from the patient to the clinician. The tests with the highest diagnostic accuracy seem to be Dial test in the prone position at 30 and 90 degrees, posterolateral drawer test, and varus stress test which corresponds to the modified Hughston classification system (Boden et al., 2010; Hassebrock et al., 2020; Yu & Garrett, 2007). First line imaging should consist of at least 2-view x-rays of the knee which may reveal abnormalities to the lateral femoral condyle or fibular head. Long-leg x-rays may also be used in chronic cases to explore length leg and this may help guide the orthopedic surgeon if a high-tibial osteotomy is needed (Bolog & Hodler, 2007; Gwathmey et al., 2012b; Hash, 2013). Using the modified Hughston scale, grade 1,2 injuries are managed with exercise therapy with a knee immobilizer for about 4 weeks followed by a progressive resistance training program that emphasizes quadriceps strength. Grade 3 injuries are managed surgically due to the high amount of rotary instability and poor long term patient reported outcomes (Geeslin et al., 2016; Sakryd & Martindale, 2020; Snyder-Mackler, 2001). The surgical technique that guides grade 3 injuries or concomitant grade 2 injuries depends on the timing when the injury is diagnosed. Acute injuries may be managed surgically with a PLC repair, although this is rare due to its misdiagnosis. Chronic injuries are best managed with an anatomic reconstruction vs non-anatomic reconstruction of the PLC (Bonanzinga et al., 2015; Dean & LaPrade, 2020; Fanelli et al., 2009). Rehabilitation is well the research seems to drop off a steep cliff, there is a lack of guidelines and recommendations in return to sport after PLC injury. The current research is summarized as at least a 4 week immobilization in knee extension except when doing rehabilitation exercises. After surgery, weight bearing status begins after 6 weeks when progressive strength exercises are incorporated. After surgery, hamstring strengthening is limited for 8-12 weeks to protect the PLC.

Post-Operative Rehabilitation

The knee is primarily a hinge joint at the mercy of the proximal hip and distal foot/ankle complex (Flandry & Hommel, 2011; Goldblatt & Richmond, 2003). Compensations at the knee therefore will affect both joints in activities of daily living and athletic activities. Thus, rehabilitation after PLC is crucial for a return to performance. Recently, the return to performance paradigm has been split into 3 main categories: return to play, return to sport, and return to performance ((Buckthorpe et al., 2019b). This paper will strive to reach a return to performance defined as playing at or above previous competition level. This section is not meant to be used as a substitute for post-operative instructions from the orthopedic surgeon or rehabilitation clinician, but rather to supplement the different phases of rehabilitation due to lack of research. Rehabilitation after PLC injury should focus on hip strength, knee strength, and knee stability (Chahla et al., 2019a; Shon et al., 2017b). This is achieved by taking into consideration the current deficits of the athlete, their goals, and needs analysis from their respective activity/sport. The rehabilitation program should focus on three pillars: strengthening the posterior chain, strengthening the lateral chain, and restoring stability of the knee.

Posterior chain

The posterior chain consists of the muscles from the low back and extends distally into the gastrocnemius/soleus complex and finally plantaris muscle (de Ridder et al., 2013; Hibbs et al., 2008; Lane & Mayer, 2017). Its importance can't be understated due to the gluteal-hamstring complex and their contribution to hip extension, knee flexion, and overall sporting activities that involve triple extension (Presswood et al., 2008; Stastny et al., 2016). Active hamstring strengthening in limited during the first 8-10 weeks of PLC reconstruction allow time for the graft to incorporate.

Lateral Chain

The lateral chain consists of the quadratus lumborum, IT band and the interface from the TFL and gluteus maximus (Wilke et al., 1995). Due to their positions and action as abduction, the gluteus medius and minimus are included in this muscle chain (Presswood et al., 2008; Stastny et al., 2016). Distal to the knee, the peroneal group continues the lateral chain into the lateral plantar muscles (adbuctor digiti mini, flexor digiti minimi brevis, opponens digiti minimi) (Wilke et al., 1995). The lateral chain is important due to the injury mechanism of PLC injuries. The lateral chain is directly responsible for resisting laterally directed forces and secondarily postero-laterally directed forces to the knee (Chahla et al., 2016c; Edson, 2003; Lynch et al., 2017). In the RTP continuum, these exercises aid in restoring stability to knee as the athlete begins to resume their sport.

Single-Leg Stance

Activities of daily living such as walking and many movements in sport involve single leg stance. In

Basketball, jumping up for a rebound may occur on one leg while in soccer a quick lateral may put all the weight on a single limb (Dingenen et al., 2016; Reimer & Wikstrom, 2010). As movement becomes faster and more stressful, the more important single leg stability becomes. The athletes may be apprehensive and demonstrate kinesiophobia with these movements that bear weight on the recovering limb (Dingenen et al., 2015). Clinicians should be mindful of this and be aware of the psychological obstacles that accompany injury (Domenech et al., 2013; Doménech et al., 2014; Flanigan et al., 2013). Considerations when taking into account exercise selection for the patients; vary the stance and foot position of exercises if traditional double limbed athletic stances recreates pain or symptoms. Larger (wider) stances cause the hip and knee joint to exert more force to lift a load due to the non-favorable less vertical lever, thus increasing their recruitment placing more stress on the knee (Coratella et al., 2021; Lee & Denton, 2015). A staggered stance exercise such as the split squat or Bulgarian split squat in later phases of rehab may be beneficial in limiting the amount of frontal, sagittal, and transverse plane stress placed on the knee. In a staggered stance position, the individual increases their sagittal plane base of support, resulting in less needed ankle dorsiflexion, less knee flexion, thus less rotational torque on the knee as it is positioned more midline and flexes less. All of this is accomplished while still allowing the patient to drive knee and hip extension while loaded and assisting rehab of the posterior and lateral chain muscle groups to enhance patient outcome. The staggered split squat or Bulgarian split squat allows for progression with foot placement close or farther away from the torso, progressively increasing knee or hip flexion.

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