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Modern concepts of diagnostics of posterolateral corner knee injuries

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Injuries to the posterolateral corner (PLC) of the knee are usually not initially apparent, and diagnosis and treatment require a full understanding of the functional interactions of their structures, as well as a specific history and complete physical examination. Objective. To summarize current concepts regarding the anatomy, biomechanics, and diagnosis of PLC injuries of the knee and to outline directions for improving the diagnostic algorithm. Materials and methods. A narrative review of publications indexed in PubMed, Scopus, and Google Scholar was conducted, focusing on anatomical and biomechanical characteristics, clinical manifestations, imaging modalities, and classification systems for PLC injuries. Results. The lateral collateral ligament, popliteofibular ligament, popliteus tendon, posterolateral capsule, and associated musculotendinous complexes were identified as the key static and dynamic stabilizers resisting varus stress and external rotation of the tibia. PLC injuries are rarely isolated; more commonly, they occur in combination with anterior or posterior cruciate ligament tears and, if not diagnosed in a timely manner, lead to chronic instability and increased load on the medial compartment of the knee. Clinical stress tests and varus stress radiography provide an approximate assessment of instability; however, existing classification systems do not fully capture the variety of injury patterns and their combinations, while the sensitivity of conventional MRI, particularly in chronic cases, remains limited. Arthroscopy may serve as an additional method for intra-articular evaluation. Conclusions. Accurate diagnosis of PLC injuries requires a standardized, multimodal approach with precise identification of the injured structures. The development of an integrated, differentiated diagnostic algorithm supported by machine-learning–based artificial intelligence tools appears to be a promising strategy for improving early detection and optimizing treatment planning.

Ушкодження задньолатерального кута колінного суглоба (ЗЛККС) зазвичай не виявляються спочатку, і для діагностики та лікування потрібне повне розуміння функціональних взаємодій їхніх структур, а також збір конкретного анамнезу та повне фізичне обстеження. Мета. Систематизувати сучасні уявлення про анатомію, біомеханіку та діагностику ушкоджень ЗЛККС й окреслити шляхи удосконалення діагностичного алгоритму. Методи. Проведено огляд публікацій з баз PubMed, Scopus і Google Scholarщодо анатомо-біомеханічним особливостей, клінічних проявів, методам візуалізації та класифікацій ушкоджень ЗЛККС. Результати. Визначено, що латеральна колатеральна, підколінно-малогомілкова зв'язки, підколінний сухожилок, задньобокова капсула та м'язово-сухожилкові комплекси є ключовими статичними й динамічними стабілізаторами, які протидіють варусному навантаженню та задньолатеральній ротації великогомілкової кістки. Ушкодження структур ЗЛККС рідко бувають ізольованими, частіше поєднуються з розривами схрещених зв'язок і за відсутності своєчасної діагностики призводять до хронічної нестабільності та перевантаження медіального відділу коліна. Клінічні стрес-тести та стрес-рентгенографія дозволяють орієнтовно оцінити ступінь нестабільності, проте наявні класифікації не повністю відображають варіанти ушкодження й їх комбінації, а чутливість МРТ, особливо в хронічному періоді, залишається недостатньою. Висновки. Діагностика ушкоджень ЗЛККС потребує стандартизованого багатокомпонентного підходу з чіткою ідентифікацією уражених структур. Перспективним напрямом є створення інтегрованого диференційованого алгоритму з використанням методів машинного навчання та штучного інтелекту для підвищення точності ранньої діагностики й оптимізації лікувальної тактики. Ключові слова. Колінний суглоб, задньолатеральний кут, зв'язки, ушкодження, нестабільність, діагностика.

Keywords. Knee, ligaments, posterolateral corner, injuries, instability, diagnostics

Introduction

The frequency of injuries to the posterolateral corner of the knee joint (PLCK) has increased due to the rise in road traffic accidents and sports injuries. Damage to the PLCK typically occurs in combination with tears of the anterior cruciate ligament (ACL) or the posterior cruciate ligament (PCL). Isolated injuries in this location are very rare, and as a result, they can often go unnoticed or be misdiagnosed [1]. In the case of delayed or absent treatment, chronic pain and residual instability can occur. Therefore, it is crucial to correctly identify and treat such injuries.

PLCK injuries are often not initially detected, and diagnosing and treating them requires a full understanding of the functional interactions between their structures, as well as a thorough patient history and complete physical examination.

Objective: To systematize current understanding of the anatomy, biomechanics, and diagnostics of posterolateral corner knee injuries and to outline ways to improve the diagnostic algorithm.

Materials and Methods

The article complies with all requirements and provisions of the Helsinki Declaration on Human Rights, the Constitution, and the basic legislation of Ukraine on healthcare, as well as ethical norms regarding clinical research (protocol No. 14 dated 26.11.2025 of the Bioethics Committee of Zaporizhzhia Medical and Pharmaceutical University). Relevant literature from the PubMed, Scopus, and Google Scholar databases was analyzed using the following keywords: knee joint, posterolateral angle, ligaments, injuries, instability, diagnostics. Articles and meta-analyses from recent years on the concept of diagnosing posterolateral corner injuries of the knee joint were selected. Inclusion criteria were original experimental and clinical studies. A total of 37 sources were analyzed.

Anatomy, biomechanics, and instability diagnostics are briefly described. The number of patients with posterolateral corner knee injuries has been steadily increasing in recent times due to combat-related injuries. This has led to the necessity of careful examination of patients with PLCK injuries, as such trauma can easily go unnoticed, leading to chronic instability.

Results and Discussion

Anatomically, the key structures in the PLCK include the lateral collateral ligament, the popliteo-fibular and popliteo-femoral ligaments, the popliteus tendon, and the posterolateral capsule (Figure 1). These structures are divided into static (intercondylar ligament and posterolateral capsule) and dynamic (biceps femoris, iliotibial tract, and the popliteal complex) components. The static structures provide resistance to varus forces on the knee. The popliteal complex consists of the tendons of the popliteal joint (musculotendinous junction of the popliteus muscle) and attaches approximately 1.3 mm distally and 0.5 mm anteriorly to the tip of the styloid process of the fibula.

Other structures that affect the stability of the PLCK include the iliotibial tract, the biceps femoris, the interosseous ligament, the middle third of the lateral capsule, and the lateral meniscus. The iliotibial tract provides lateral knee stability when excessive varus tension occurs during knee extension [2]. The biceps femoris muscle has both long and short heads, which help the knee flex and rotate laterally, ensuring dynamic stability during varus angulation. This muscle also controls the internal rotation of the tibia and works with the medial popliteal tendons to prevent excessive anterior translation of the tibia relative to the femur. The middle third of the lateral capsule serves as a secondary stabilizer for varus stability [3]. The coronary ligament of the lateral meniscus extends from the popliteal opening to the popliteomeniscal bundle and plays a role in resisting the knee when in hyperextension or posterior-lateral rotation of the tibia [4].

Therefore, the posterolateral corner of the knee is the primary stabilizer that resists varus load on the knee.

Biomechanics

The structures of the PLCK provide the primary restriction against varus forces on the knee, as well as posterior-lateral rotation of the tibia [5]. Previous biomechanical studies involving selective sectioning of structures have provided evidence of the importance

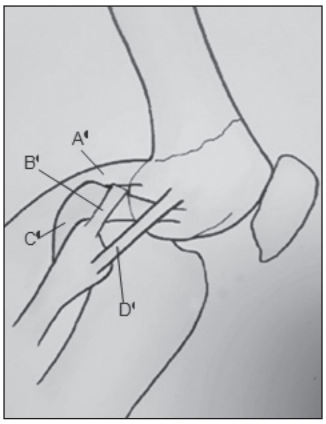


Fig. 1. Anatomical structure of the PLC: a) lateral tendon of the calf muscle; b) popliteofibular ligament; c) popliteus muscle and its tendon; d) lateral collateral ligament

of the lateral collateral ligament, popliteofibular ligament, and the popliteus tendon in resisting forces on the knee. In the absence of a cruciate ligament, these structures act as secondary stabilizers for both anterior and posterior translation of the tibia [6–10].

The lateral collateral ligament (LCL) is the primary static restraint against varus opening of the knee. Direct measurements of its force during applied varus motion demonstrate a higher reaction force at 30° flexion compared to 90°. The tensile strength of the lateral collateral ligament was determined to be 295 N. After sectioning the LCL, R. F. LaPrade and F. Wentorf [10] showed that the reaction forces at mid-range loads on external rotation of the LCL were significantly higher than those of the popliteus tendon and popliteofibular ligament at both 0° and 30° flexion, while the popliteus muscle and popliteofibular ligament exhibited higher loading at these angles.

Regarding external rotation of the tibia, the PLCK structures are the main stabilizers of its external rotation at any flexion angle. Studies such as those by D. L. Gollehon et al. [6] and E. S. Grood et al. [7] demonstrated that isolated sectioning of the PLCK results in an average increase in tibial rotation by 13° at 30° of flexion, which decreased to an average of 5.3° at 90°. Combined injury to the PLCK and posterior-lateral structures led to a significant increase in external rotation of the tibia, particularly at 90° of flexion (20.9°). Thus, combined injuries to the PCL and PLCK structures are more susceptible to external rotation forces. The dominant restraint to posterior translation of the tibia is the PCL [11]. Isolated sectioning of the PCL causes increased posterior translation of the tibia at all flexion angles, with a maximum at 90° (11.4 mm). Additional sectioning of the PLCK structures increases posterior tibial translation at all angles, with a maximum at minimal knee flexion. Thus, the PLCK structures, rather than the PCL, are the primary restraint to posterior tibial translation during near full knee extension. Combined studies of PLCK and PCL structures demonstrated a significant increase in posterior displacement (21.5 mm) at 90° flexion compared to an intact knee or isolated injuries to the PLCK or posterior-lateral insufficiency. Functional interaction between the popliteus muscle and PLCK was also confirmed — the popliteus muscle acts as both a static and dynamic stabilizer of the knee. In a cadaveric study, C. D. Harner and J. Höher [12] found that loading on the popliteus muscle in an intact joint reduced the PCL's response to posterior loading. In contrast, in a PCL-deficient model, loading on the popliteus muscle reduced posterior displacement at a maximum flexion angle of 30°.

Biomechanical analysis of posterior-lateral instability during PCL or ACL reconstruction further demonstrates the interdependent relationship between the structures of the PLCK and these ligaments. R. F. LaPrade et al. [13] noted increased loading on the PCL graft when using varus and combined varus-internal rotational moments. As a result, they recommended reconstruction or restoration of the PLCK, which is considered a secondary primary stabilizer (PCL is the primary stabilizer at lower angles, and the anterolateral ligament at larger flexion angles) to prevent internal rotation.

Any failure to recognize and treat PLCK injuries will lead to increased stress and potential failure in PCL or ACL reconstruction. Therefore, combined restoration of both the PLCK and cruciate ligaments is recommended [14]. Similarly, in the combined model of PLCK and ACL injuries developed by J. K. Sekiya et al. [15], reconstruction of both regions resulted in kinematics of the knee closer to normal.

Recently, there has been a trend toward maximal anatomical restoration, particularly of the three most important biomechanical structures controlling varus and external rotation: the lateral collateral ligament (LCL), popliteofibular ligament (PFL), and popliteus tendon. In a cadaveric study, anatomical reconstruction showed no significant difference between intact and reconstructed joints under varus loading at 0°, 60°, and 90° of flexion or under external rotational moments at any flexion angle [16]. However, some biomechanical experiments, in which all three functional components were anatomically restored, separately documented excessive restriction of internal rotation and varus deviation.

K. H. Yoon et al. [17] reported that a recently developed method of PLCK reconstruction, which does not restore the dynamic popliteus muscle, is not inferior to methods that include anatomical reconstruction of the popliteus tendon. S. Kim et al. [18] noted that the three widely accepted methods (Warren, Larson, and Kim) do not provide full restoration of the native strength of the PLCK structures.

Diagnosis

History taking

The diagnosis of PLCK injuries requires a thorough history and clinical examination to identify the signs and symptoms that may indicate this type of injury. Given the difficulty in initially detecting PLCK injuries, it is essential to gather detailed patient history, including any recent trauma or joint instability, and perform comprehensive physical examinations to assess knee stability and function.

Thorough history taking helps prevent overlooking possible PLCK injuries, a typical symptom of which is pain in the posterior part of the knee. In some patients, neurological symptoms may also be present. J. C. DeLee et al. [19] reported that peroneal nerve injury occurred in 2 out of 12 individuals with isolated posterior-lateral corner knee injuries. R. F. LaPrade et al. [20] and Y. Krukhaug et al. [21] indicated that peroneal nerve damage in patients with posterior-lateral knee injuries was observed in 13-16% of cases. Patients with chronic injuries often complain of significant pain in the medial or posterior-lateral parts of the knee [22, 23]. Additionally, signs of peroneal nerve injury, such as paresthesia or numbness, may be diagnosed. Functional instability can also be noted—during normal walking the knee remains extended, but during descending stairs, it transitions into a hyperextension state [24].

Mechanism of Injury

Posterior-lateral corner knee injuries are typically associated with sports, falls, and road traffic accidents. A direct blow to the proximal tibia while the knee is in the extended position may result in an isolated injury to the posterior-lateral section. A combination of hyperextension and varus forces on the knee, especially when the knee is in a flexed position or the tibia is in external rotation, can also lead to injury of the posterior-lateral structures. A lateral dislocation of the knee joint can also cause these injuries.

Clinical Examination: Symptoms and Signs

Symptoms of posterior-lateral corner injury include a wide range of pain, swelling, and stiffness. In addition, attention should be paid to the alignment of the lower extremities during standing and walking.

Standing Position: Patients with PLCK injury are likely to have an abnormal deviation of the lower extremity axis. In the standing position, varus deformity of the knee may be observed [25, 26].

Gait. When static stabilizers of the knee are injured, dynamic stabilizers cannot function properly due to the lateral joint gap opening and the protrusion of the femoral condyle and lateral tibial plateau. This causes varus deformation during the stance phase of walking, leading to an abnormal gait pattern [27, 28]. Varus displacement of the knee is observed during the stance phase of walking and in cases of long-standing injury to the posterior-lateral structures of the knee (Fig. 2). Typically, the gait pattern is accompanied by the opening of the lateral knee compartment, which increases the load on the medial part of the joint. If the instability is untreated, it leads to cartilage wear in the medial half of the joint [29]. Sometimes, patients exhibit a fixed knee gait due to adaptation to knee instability.

Dial Test. The Dial test is one of the most important physical examinations used to diagnose PLCK injury. When the patient is in a supine position, external rotation of the tibia and the angle between the femur and foot are assessed. This test is performed with the knee flexed at 30° and 90° (Fig. 3). In the case of isolated PCL injury, external rotation of more than 10° is observed at 30° of flexion. For combined injuries of the PCL, more than 10° of external rotation occurs at both 30° and 90° of flexion.

External Rotation and Recurvatum Test. This test can be used to assess posterior-lateral rotational instability of the tibia. Varus deviation is measured by comparison with the contralateral knee.

Posterior-Lateral Drawer Test. This test is performed by applying a posterior-lateral force to the proximal tibia with the hip flexed at 45° and the knee at 90°, externally rotated 15° in a supine position. When the lateral tibial condyle experiences more external rotation than the lateral femoral condyle, it indicates the presence of posterior-lateral injury (Fig. 3).

Posterior-Lateral External Rotation Test. This test is a combination of the Dial test and the posterior-lateral drawer test. The posterior-lateral subluxation of the tibia is tested by simultaneously applying posterior and external rotational forces to the knee joint. Subluxation during flexion at 30° suggests an isolated posterior-lateral injury. With combined injury involving the PCL, subluxation occurs at both 30° and 90° of flexion.

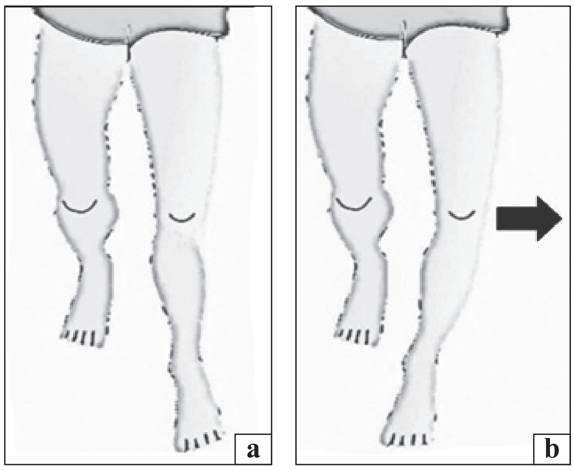


Fig. 2. Images of knee joints during walking: a) normal gait during the knee's reaction phase to load; b) dynamic varus deformity characteristic of posterior-lateral corner injury

Reverse Pivot Shift Test. This test is performed with the knee flexed at 40° and the tibia externally rotated. During extension, the tibia moves with a “clunk”, which indicates the presence of PLCK injury. However, when the test is performed under anesthesia, false positive results occur in up to 35 % of cases.

Varus Stress Test. The varus stress test is performed by applying pressure during knee flexion at 20°–30° to diagnose posterior-lateral instability. If the lateral collateral ligament is intact, no increase in the varus gap is observed during 20°–30° of knee flexion. In the case of combined injuries to other structures such as the popliteal tendon or popliteofibular ligament, an increase in the varus gap may be observed. The physician applies pressure along the joint line to stabilize the distal femur, then applies the varus load. The degree of instability is evaluated by measuring the varus gap on a radiograph under load.

Differential Diagnosis. Simple radiography in direct, lateral, and axial projections is conducted to rule out other injuries, such as fractures. In the direct projection, expansion of the lateral joint gap or metaphyseal avulsion fractures of the tibia or fibula can be seen [25].

For chronic injuries, a direct projection of the legs in a standing position may be performed to assess limb alignment. This alignment should be corrected via osteotomy before or during the reconstruction procedure [30, 31].

Radiographic images with load bearing in the posterior-lateral corner of the knee joint in the standing position are highly informative for diagnosing injuries. R. F. LaPrade et al. [32] studied varus stress radiographs of the knee joint at 20° of flexion to provide objective measurements of the lateral compartment gap (Fig. 4).

An increased gap greater than 4 mm may indicate a Grade III posterior-lateral corner injury. Radiographic images also facilitate the objective quantitative evaluation of isolated or combined posterior-lateral corner injuries [33] (Table 1).

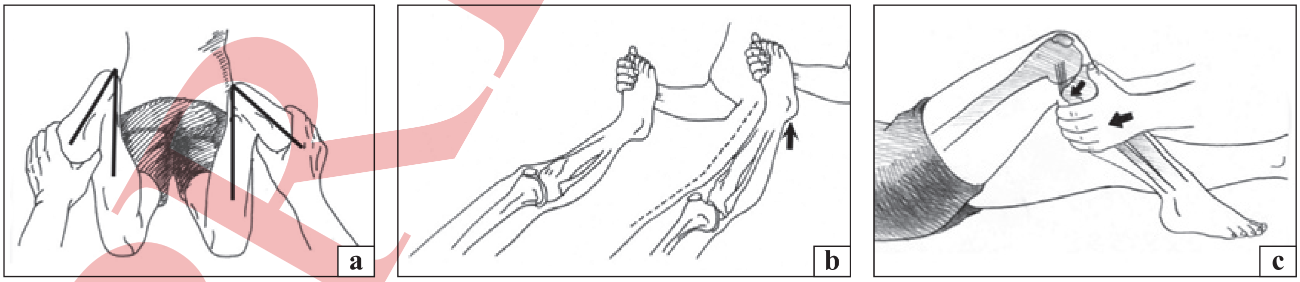
Magnetic Resonance Imaging (MRI) can be useful when injuries to the posterior-lateral structures are difficult to diagnose clinically. It helps identify the injured structures. Specifically, coronal oblique projections with T2-weighted imaging are more useful for analyzing posterior-lateral structures than traditional coronal or sagittal views. MRI is more suitable for detecting acute or subacute posterior-lateral corner injuries (Fig. 5). Therefore, MRI should be performed within the first 12 weeks, as only about 26 % of cases may be diagnosed after this period [34].

Arthroscopy provides intra-articular information about the posterior-lateral structures, such as the popliteal complex, the coronary ligament of the lateral meniscus, and the posterior-lateral capsule. It helps determine the appropriate treatment and provides final anatomical information during surgical treatment.

A lateral opening of more than 1 cm under varus loading on the knee joint, which can be confirmed by arthroscopy, is shown in Fig. 6. Additionally, during surgery, one can observe the enlargement of the popliteal opening with internal rotation of the tibia, rupture of the upper and lower popliteomeniscal bundles, and abnormal popliteomeniscal movement during rotation [35].

Classification

PLCK injuries can be classified based on the damaged structures or the degree of posterior-lateral



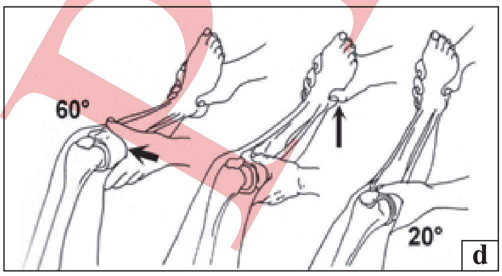


Fig. 3. Manual testing for posterior-lateral instability: a) Cooper's external rotation asymmetry test, or the Dial test, performed at 90° and 30° flexion; b) Hagston and Norwood’s external rotation hyperextension test; c) posterior drawer sign; d) reverse Pivot-Shift test according to Jakob

instability. The two most commonly used classifications are:

1. R. Bleday et al. [36] and G. C. Fanelli with R. V. Larson [37] Classification

This classification divides injuries into types A, B, and C based on the injured structures (Table 2):

– Type A — Popliteofibular ligament and popliteus tendon. Clinically, only an increase in external rotation of the tibia is observed.

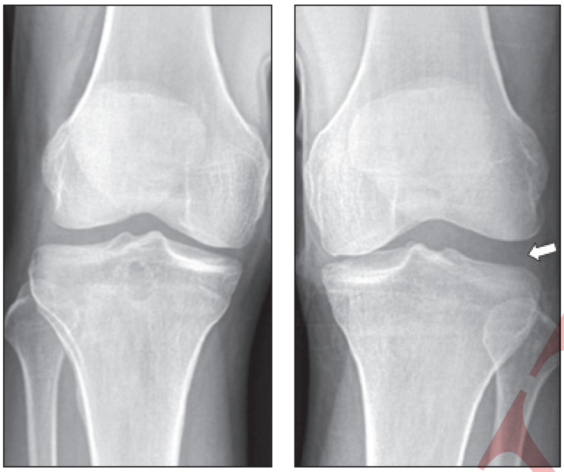


Fig. 4. X-ray with varus loading showing increased lateral joint space widening, indicated by an arrow in the injured knee

– Type B — Popliteofibular ligament, popliteus tendon, and lateral collateral ligament. Mild varus opening is observed during the varus stress test at 30° of knee flexion, along with an increase in external rotation of the tibia.

– Type C — Popliteofibular ligament, popliteus tendon, lateral collateral ligament, lateral capsule avulsion, and cruciate ligament tear. Marked varus instability is observed with knee flexion at 30°.

2. J. Hughston Classification

This classification is based on studying varus or rotational instability under the action of varus stress at full knee extension [22], and it has three grades:

– Grade I — Minimal ligament rupture without abnormal motion.

– Grade II — Partial rupture with mild to moderate abnormal motion.

– Grade III — Complete rupture with pronounced abnormal motion.

The Hughston classification for posterior-lateral instability considers only clinical signs that can be identified through objective manual examination of the patient. It is based on the study of varus and rotational instability (Table 3). Despite its subjectivity and lack of anatomical correlation with dissection

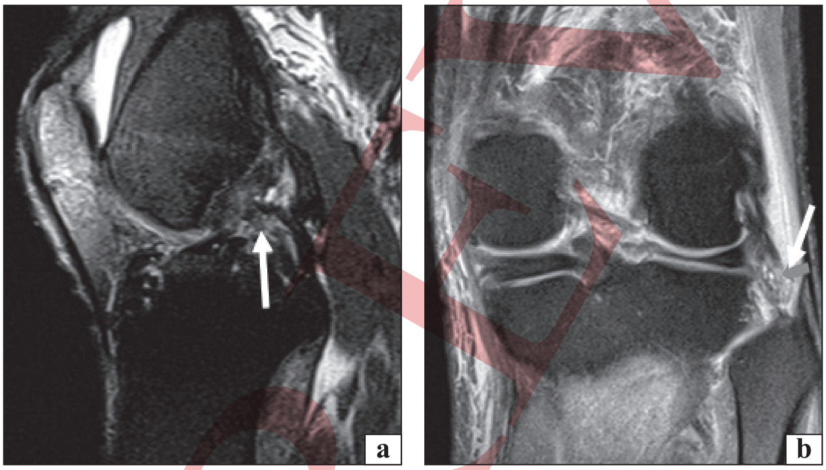


Fig. 5. Sagittal and coronal MRI scans of an angular injury in the left knee: a) rupture of the PCL (arrow) visible in the sagittal projection; b) high signal on the lateral collateral ligament (arrow) visible in the coronal projection

Table 1

Assessment of instability using stress X-rays

Deviation indicator	Injury
Lateral opening during varus stress (mm) < 2,7	Normal or minimal
2,7–4	Complete rupture of the lateral collateral ligament
> 4	Complete injury of the PLCK
Posterior tibial load (mm) < 4	Normal or minimal
4–12	Isolated PCL injury
> 12	Complete PCL and PLCK injury

Table 2

Classification of PLCK injuries by G. C. Fanelli and R. V. Larson

Тип	Description	Structure
A	Increased external rotation of the tibia by 10°	*lig. popliteofibulare*, tendon of the *m. popliteus*
B	Increased external rotation of the tibia by 10°. Lateral compartment opening during varus stress test by 5–10 mm	*lig. popliteofibulare*, tendon of the *m. popliteus* *lig. collaterale fibulare*
C	Increased external rotation of the tibia by 10°. Lateral compartment opening during varus stress test by more than 10 mm	*lig. popliteofibulare*, tendon of the *m. popliteus* *lig. collaterale fibulare* joint capsule, PCL

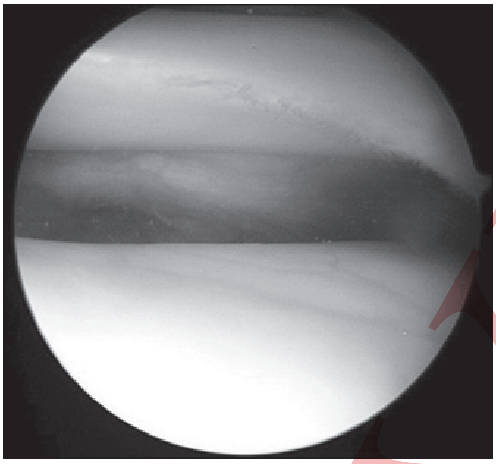


Fig. 6. Lateral compartment opening of the knee joint during arthroscopy,

studies, this classification method remains important for determining the choice of treatment.

Conclusion

The diagnosis of injuries to the structures of the PLCK remains an insufficiently addressed issue in knee joint injury management. There are no clear definitions for the degrees of posterior-lateral instability, and the existing classifications provide only a superficial understanding of the structures and combinations of injuries. The interpretation of clinical symptoms and manual tests is mostly empirical and individualized. Recommendations to use stress radiographs for analyzing the degrees of posterior-lateral instability are not always clearly implementable. The most accurate approach may be to precisely define the damaged structures, but their visualization is complicated by the limited sensitivity of MRI studies in conventional sequences, and coronal oblique projections are usually not employed. MRI sensitivity decreases over time and is significantly reduced after 6 weeks post-injury. Diagnosing injuries to the posterior-lateral corner structures requires a more modern approach, using an integrated, differentiated diagnostic algorithm, possibly incorporating machine learning and artificial intelligence.

Table 3

Classification of posterior-lateral instability by J. Hughston

Degree of injury	Varus and rotational instability
I	0–5 mm and 0°–5°
II	5–10 mm and 6°–10°
III	> 10 mm and > 10°

Posterior-lateral reconstructive surgery has shown better results than simple restoration or suturing when surgically treating PLCK injuries. Anatomical posterior-lateral reconstruction of the structures is recommended both during the acute phase and in the case of chronic instability. There are two types of plastic reconstructions: one based on fixation of the fibula to the femur and the other based on fixation of the tibia and fibula head to the lateral femoral condyle. Currently, the method based on fixation of the tibia to the femur is considered superior to the method involving the binding of the fibular head to the femoral condyle.

The graft used to connect the tibia to the femur acts as a rigid augment for the popliteal muscle, which presents a contradiction. Its fixation point on the posterior surface of the tibia is chosen empirically, in the projection of the popliteus tendon. However, it shortens depending on the rotational movements of the shin relative to the femur, and the tendons are displaced. This augmentation with a constant-length graft to restore the popliteal tendon is not anatomical, and the fixation points are generally debatable.

Thus, the main issues lie in the insufficient anatomical nature of existing reconstruction methods for the structures of the posterior-lateral corner of the knee, their traumatic nature, and the lack of precise positioning of the graft fixation points.

Conflict of Interest. The authors declare no conflict of interest.

Prospects for Further Research. Further research is planned to focus on creating and validating an integrated, differentiated algorithm for diagnosing posterior-lateral corner injuries, considering clinical tests, stress radiographs, and extended MRI protocols, including coronal oblique slices. The use of machine learning methods to enhance imaging sensitivity, objectively assess the degrees of instability, and optimize treatment strategies is promising.

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Authors' Contributions. Holovakha M. L. — Setting the goal and tasks of the study, writing the manuscript. Bondarenko S. A. — Analyzing the primary material. Bezverkhyi A. A. — Accounting for the primary material and performing statistical analysis.

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MODERN CONCEPTS OF DIAGNOSTICS OF POSTEROLATERAL CORNER KNEE INJURIES

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