International Journal of Pharmaceutical Research and Applications
Volume 11, Issue 2 Mar - Apr 2026, pp: 1105-1120 www.ijprajournal.com ISSN: 2456-4494

Comprehensive Review of Multi-Ligament Knee Injuries: Clinical Implications of Combined Acl, Pcl, Mcl and Meniscal Damage

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Date of Submission: 15-04-2026 Date of Acceptance: 25-04-2026

ABSTRACT
Multi-ligament knee injuries (MLKIs) are one of the most complicated and incapacitating musculoskeletal system injuries. These injuries entail the destruction of two or more of the principal knee stabilizers, which are mainly the anterior cruciate ligament (ACL), posterior cruciate ligament (PCL), medial collateral ligament (MCL), and the meniscus. High-energy trauma, sports-related injuries, sudden twisting, or direct knee-joint impact are often linked with such injuries. The concomitant rupturing of several ligaments seriously affects the joint stability, biomechanics, and functional mobility, and usually results in long-term complications in case of improper diagnosis and treatment.
This review paper will set out to give a concise overview of multi-ligament knee injuries that involve the ACL, PCL, MCL, and meniscus in terms of their relevance to the anatomy, injury mechanisms, diagnosis, management plans, and rehabilitation measures. The focus is given to the existing clinical strategies and imaging techniques such as magnetic resonance imaging (MRI), surgical reconstruction, and organized physiotherapy programs aimed to restore stability and functionality of joints.
Also, the review describes the significance of early diagnosis, multidisciplinary approach, and customized rehabilitation in enhancing patient outcomes and avoiding chronic instability or degenerative joint diseases like osteoarthritis. To demonstrate the clinical course and rehabilitation issues related to complex knee ligament injuries, a brief experiential reflection on the basis of personal injury is also included. This is because the complexity and management of such injuries is necessary in enhancing the result of treatment and further research in the orthopedic and sports medicine fields.
Keywords: Multi-ligament knee injury, Anterior cruciate ligament (ACL), Posterior cruciate ligament (PCL), Medial collateral ligament (MCL), Meniscus injury, Knee biomechanics, Sports injury, Knee instability, Ligament reconstruction, Rehabilitation.

I. INTRODUCTION

Knee joint is believed to be among the largest and most complex joints in the human body that is critical in providing stability, movement and weight support in the day to day activities of the human being in the form of walking, running and jumping. A complex of ligaments, cartilage, muscles and soft tissues structurally stabilize the knee joint to achieve a smooth coordinated movement(Hirschmann & Müller, 2015). The anterior cruciate ligament (ACL), posterior cruciate ligament (PCL), medial collateral ligament (MCL), and the meniscus are some of these structures, which are important to ensure stability and functional integrity of the knee joint. Damage to either of these structures can have a devastating impact on the performance of the joints and can result in instability, pain and immobility(Innocenti, 2022).

Multi-ligament knee injury is an illness that is characterized by the destruction of two or more of the large stabilizing ligaments of the knee. They are not very common as isolated ligament injuries but are deemed to be more serious because of the complicated nature of the structures affected and the immense effect on knee stability. Combined injuries to ACL, PCL, MCL, and meniscus are often causes of high-energy traumas, injuries related to sporting activities, road carnage, or sudden twists and rotational forces on the knee joint. Such injuries may result in other chronic complications such as chronic instability, cartilage degeneration and early onset of osteoarthritis unless they are adequately diagnosed and treated(Fortier et al., 2022).

The multi-ligament knee injuries are normally diagnosed through the combination of the clinical assessment and imaging systems such as the magnetic resonance imaging (MRI) that is used to assess the extent of the injury on the ligaments and meniscus(Sanchez-Munoz et al., 2023). The

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Volume 11, Issue 2 Mar - Apr 2026, pp: 1105-1120 www.ijprajournal.com ISSN: 2456-4494

level of injury may vary the management strategies, which may include conservative intervention, re-injury of the damaged ligaments and formal rehabilitation programs aimed at achieving joint stability and functional movement.

This review paper aims to provide a thorough review of the multi-ligament knee injuries implicating ACL, PCL, MCL and meniscus. It discusses anatomical shapes of knee joint, common injury mechanisms, diagnostic devices, management strategies, and rehabilitation strategies. This review intends to provide a summative of the available evidence and clinical practice to highlight why early diagnosis is important, effective rehabilitation and proper management is required to improve the outcome of recovery among patients with complex knee ligament ruptures

Anatomy of the knee joint

Knee joint is a hinge joint and the most complex and largest synovial joint in human body as it allows flexion, extension and a little rotation. It is very important in bearing body weight and facilitating movements like walking, running, jumping and squatting. The knee joint is mainly constituted by the connection of three bones; the femur (thigh bone), tibia (shin bone), and patella (kneecap)(Abulhasan & Grey, 2017). These structures are made up of a combination of ligaments, tendons, cartilage and the surrounding muscles that provide the structure with the necessary stability and facilitates the smooth movement of the structure when one engages in physical activities.

Ligaments are tough strands of connective tissue that attach bones and give mechanical stability to the knee joint. The knee has four largest ligaments which are anterior cruciate ligament (ACL), posterior cruciate ligament (PCL), medial collateral ligament (MCL) and lateral collateral ligament (LCL). The ACL and PCL are found in the middle of the knee joint and they have a cross-like appearance which helps in determining the forward and backward movement of the tibia in relation to the femur. ACL inhibits anterior tibial movement, and assists in rotational stability but the PCL inhibits posterior tibial movement and is important in knee stabilization during flexion(Iwanaga et al., 2025).

The collateral ligaments are on the side of the knee joint and provide resistance to the side forces. MCL is found on the inner side of the knee and it assists in resisting the valgus stress, which occurs when the knee is pulled towards the inner. Lateral collateral ligament (LCL) is, on the other hand, located on the side of the knee and is in opposition to varus stress, which out of shapes the knee(Juneja & Hubbard, 2019). All these ligaments help in keeping the knee joint structure intact when it goes through a number of motions and external forces.

Besides ligaments, there are also two crescent-shaped fibrocartilaginous bodies called the medial and lateral menisci that make up the knee joint. Menisci serve as shock absorbers in between the tibia and the femur and evenly distribute body weight around the joint that reduces friction during movement. They also work towards joint stability and in the process prevent the articular cartilage against undue strain. Damage to the meniscus can result in knee pain, swelling and loss of range of motion, which can greatly affect knee functionality(Chirichella et al., 2019).

Overall, the joint action of bones, ligaments, cartilage, and the soft tissue surrounding the knee joint allows the joint to work efficiently and be at the same time stable and flexible. Knowledge of the anatomical layout of the knee joint is vital in identifying the mechanisms, diagnosis and treatment of intricate trauma of several ligaments and meniscal damage(Gupton &Terreberry, 2020).

Figure 1: Anatomical Structure of the Knee Showing ACL, PCL, MCL and Meniscus

Table 1: Major Ligaments of the Knee and Their Primary Functions

Ligament	Location	Primary Function
Anterior Cruciate Ligament (ACL)	Center of knee joint	Prevents forward movement of the tibia and provides rotational

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		stability
Posterior Cruciate Ligament (PCL)	Center of knee joint	Preventsbackward displacement of the tibia
Medial Collateral Ligament (MCL)	Inner side of the knee	Resists valgus stress and stabilizes the medial knee
Lateral Collateral Ligament (LCL)	Outer side of the knee	Resists varus stress and stabilizes the lateral knee

Anterior Cruciate Ligament (ACL)

One of the most important knee joint stabilizing ligaments, which is a critical part of the maintenance of the mechanical stability and functional movement of the knee, is the anterior cruciate ligament (ACL). It is found in the middle of the knee joint where the femur (thigh bone) is joined to the tibia (shin bone). The ACL anatomically has its origin on the posterior part of the lateral femoral condyle and inserts on the anterior intercondylar region of the tibia. It is this positioning that enables the ligament to regulate the anterior movement of the tibia in relation to the femur as well as provide stability during dynamic movements like running, jumping, pivoting, and abrupt change of direction(Lukas et al., 2022). The ACL consists of powerful collagen fibers that are organized in bundles and are mainly referred to as the anteromedial and posterolateral bundles, working collectively to enable stability in the varying degrees of knee movements(Morales-Avalos et al., 2024).

The ACL functions to prevent anterior tibial translation and restrains rotational forces that may cause instability in the knee joint. It is also relevant in proprioception meaning the capacity of the body to determine the position and movement of the joints. Due to these functions, ACL is especially susceptible to damage in high impact sports or activities which require sudden direction changes, rapid deceleration, or improper landing techniques(Greiner et al., 2024). ACL tears constitute some of the most frequent ligament tears in the knee that may be either partial or complete. In case of ACL damage, a popping sensation during injury, pain, swelling, joint instability, and inability to bear weight on the injured leg are some common symptoms experienced by the patient. Untreated ACL injuries may also result in chronic knee instability, additional damage to the surrounding structures (meniscus), as well as a greater risk of early onset osteoarthritis(Sharma, 2021). This means that correct diagnosis and proper management, including surgery to rebuild the knee and rehabilitation where required is vital to regaining stability and functional performance of the knee.

Posterior Cruciate Ligament (PCL)

One of the primary supporting ligaments of the knee joint, that is believed to be the strongest and thickest ligament in the knee, is the posterior cruciate ligament (PCL). It is found in the deepest part of the knee joint and is in coordination with the anterior cruciate ligament (ACL) to regulate the forward and backward motion of the tibia with respect to the femur. The PCL anatomically will originate on the lateral surface of the medial femur condyle and will insert into the posterior intercondylar region of the tibia. The PCL is important in the prevention of anterior displacement of the tibia and stability of the knee joint during movement especially when the knee is flexed(Chahla et al., 2020).

The PCL functions as the major restraint of the posterior translation of the tibia and functions as a whole to maintain stability of the knee during walking, ascending the stairs, and squatting. It also helps in restraining rotational movements of the knee and also preserving the correct position of the femur and tibia when performing weight-bearing activities. Despite the fact that the PCL is more robust than the ACL and is not commonly injured, it can be damaged under specific circumstances, especially due to high-impact trauma(Winkler et al., 2021). A blow to the front of the tibia whilst the knee is bent, what is sometimes known as a dashboard injury, is one of the most common causes of PCL injury, and is common in road traffic accidents. Severe hyperflexion or hyperextension of the knee during sports or physical activities also may cause PCL injuries(Verhulst & MacDonald, 2020).

Patients with PCL injury might complain of knee pain, swelling, stiffness and the feeling of instability, particularly when walking down the hill or stairs. PCL injuries in most instances come with other ligament injuries, which complicate multi-ligament knee injuries. Clinical examination tests and imaging methods like magnetic resonance imaging (MRI) are normally used to diagnose the extent of damage to the ligament(Gao et al., 2025). The treatment can be different based on the level of injury and can involve conservative therapy with physiotherapy and strengthening exercises or even

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Volume 11, Issue 2 Mar - Apr 2026, pp: 1105-1120 www.ijprajournal.com ISSN: 2456-4494

surgical repair of the case of severe or combined injuries of the ligaments. Knee rehabilitation requires proper rehabilitation to reestablish knee functionality, stability and long-term joint well-being(Kew et al., 2022).

Medial Collateral Ligament (MCL)

One of the major stabilizing ligaments of the knee joint is the medial collateral ligament (MCL), which is on the inner or medial side of the knee. It attaches the medial femoral condyle of the femur with the medial surface of the tibia and is an important structure in ensuring structural stability of the knee. The MCL is a wide, flat band of ligament tissue fibers that consist of strong connective tissue and are structured to resist valgus stress which is a force that causes the knee to be drawn towards the inside. The anatomical location and the action of the MCL combine with the other knee ligaments in ensuring that the joint is in the right position throughout movement and weight-bearing processes.

The MCL functions to stabilize the knee by preventing excessive knee side to side movement and supporting the joint during movement like walking, running, and sudden turns. It also aids in the stabilization of rotations in the case of the knee when external forces are applied to the knee. The ligament is broken into superficial and deep components, which help in the overall stability of the knee. The deep part of the MCL is closely related to the medial meniscus such that in some cases, when the MCL is injured it also damages the medial meniscus(Lundblad et al., 2019).

MCL injuries are usually caused by a direct blow to the outer side of the knee, which causes the knee to bend inwards and undue pressure to be exerted on medial structures of the joint. These injuries are common in contact sports like football, rugby and basketball and in accidents where there is sudden twisting or impact on the knee. An MCL injury is normally accompanied by pain on the inner part of the knee, swelling, tenderness, as well as instability during movement. MCL injuries can be mild stretching of the ligament fibers or rupture depending on the severity of the injury. MCL injuries, which are of mild to moderate severity, in most circumstances, are treatable in conservative management via rest, bracing, and physiotherapy. Nevertheless, more serious injuries, in particular, those related to other ligament or meniscal ruptures, might demand surgical and systematic rehabilitation to recover normal knee functioning and stability(D'Ambrosi et al., 2021).

Lateral Collateral Ligament (LCL)

Lateral collateral ligament (LCL) is one of the major stabilizing ligaments in the knee joint located on the outer (lateral) part of the knee. It is a structural band, which connects the lateral epicondylar femur and the head of the fibula and is a key structure in the knee that promotes structural stability of the knee particularly when forces are directed towards causing the knee to bend to the outside. LCL is a coordinated arrangement of the other knee ligaments and soft tissue construction to ensure they keep good alignment and a controlled movement in the course of various physical processes such as walking, running and jumping(Shetty et al., 2021).

The LCL acts structurally to counteract varus stress that is caused by an external force that pulls the knee outwards, and the foot is relocated. The LCL also helps to maintain the mechanical stability of the joint by preventing undue lateral movement of the knee and also by making sure the surrounding structures are not under undue stress. The LCL in contrast to the medial collateral ligament (MCL) is not directly connected to the lateral meniscus, allowing it a bit more freedom(Yaras et al., 2020). This anatomy however means that tears of the LCL often occur in conjunction with other structures of the posterolateral knee like popliteus tendon, and other stabilizing structures.

The damage of the LCL is less common than the damage of the ACL, MCL but can also occur along with the direct traumas or the excessive varus forces on the knee. Such injuries are typical in contact sports, falls/accidents, when a blow is delivered to the inner part of the knee, pushing it out. Presence of pain and tenderness on the outer side of the knee, swelling, joint instability, and inability to bear weight or move are some of the symptoms that can be used to characterize an LCL injury(Yasen & Mabrouk, 2026). In more dire circumstances, patients may be discovered to be physically unstable as they find it difficult to balance themselves to perform physical activities.

Clinical examination and other forms of imaging such as magnetic resonance imaging (MRI) are typically used to diagnose LCL injuries to ascertain the level of damage to the ligament and other injuries. Treatment also depends on the extent of the injury and may incorporate the application of conservative treatment in the form of rest, bracing, and physiotherapy when there is mild injury but more severe ligament tears or intricate injuries to a

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ligament may require surgery to re-repair(Braaten et al., 2022). The post-treatment rehabilitation is pivotal in restoring the stability of the knee, the strength of muscles and enabling persons to resume safely in their usual activities or participate in sporting activities.

Meniscus

The Meniscus is an important fibrocartilaginous structure of the knee joint that is crucial in ensuring stability of the knee joint, distribution of loads, and shock absorption. The knee has two menisci: medial meniscus on the inner side of the knee and the lateral meniscus on the outer side. These are crescent formations that are placed between the bones of the thigh (femur) and the shin (tibia) and serve as a way of enhancing the congruency of the articulating surfaces of these bones. The menisci evenly redistribute body weight over the knee joint and thus aid in minimizing strain on the articular cartilage and preventing undue wear and tear during motion(Biçer et al., 2015).

The menisci play a functional role in the knee with regards to stability, lubrication and proprioception of the joint. They serve as shock absorbers when one walks, runs and jumps; they cushion the forces that are passed in the knee joint. Moreover, the menisci also contribute to the normal movement of the joints and adds stability to the joints that are supported by the surrounding ligaments(Cognetti & Bedi, 2025). The medial meniscus is less mobile and is more vulnerable to trauma than the lateral meniscus since it is more firmly fixed to the joint capsule and medial collateral ligament (MCL). Due to this anatomical connection, medial meniscus injuries are frequently associated with either the ACL or MCL injuries.

Injuries of the meniscus are usually caused by sudden twists or rotational knee movements especially when the foot is stabilized on the ground as the body is redirected. These injuries are common among athletes who engage in sports that require them to make pivots like in football, basketball and soccer. Knee pain, swelling, stiffness, restricted range of movement, and a feeling of locking or catching in the joint are a few symptoms of a meniscal injury. People can also have a problem with complete extension or bending of the knee in certain instances. The diagnosis is usually through clinical examination and imaging, which includes magnetic resonance imaging (MRI) and can help establish where the tear is, and how serious it is(Marigi et al., 2024). The management is dependent on the nature and severity of the injury and can involve either conservative management by resting and physiotherapy or surgical management like meniscal repair or partial meniscectomy in order to regain normal knee function and prevent long term degeneration of the joint.

Epidemiology of Multi-Ligament Knee Injuries

Multi-ligament knee injuries (MLKIs) are not very common, but they are some of the most serious types of knee injuries experienced in orthopedic practice. These are injuries in which two or more of the main stabilizing ligaments of the knee (the anterior cruciate ligament (ACL), posterior cruciate ligament (PCL), medial collateral ligament (MCL), lateral collateral ligament (LCL) or other ligaments, such as the meniscus, are all damaged at the same time. According to epidemiological work, the number of MLKIs is less than 0.02 of all orthopedic injuries, which are, in other words, much less common than isolated ligament injuries(Murray et al., 2024). Nevertheless, their low prevalence, although, they are clinically important as they are difficult to diagnose, treat, and rehabilitate to resume normal knee stability and functioning.

Most cases of multi-ligament knee injuries are involved in young and physically active patients, especially athletes who are involved in high intensity sports like football, basketball, rugby, and skiing. These injuries are normally caused by sudden twisting or rapid deceleration of a sport or high impact collision in a sport that exerts undue strain on the knee joint(Pardiwala et al., 2021). Besides sport injuries, the MLKIs are also often related with high-energy trauma, such as road traffic accidents, falls, and blows to the knee directly in the course of physical endeavors. In this regard, the injury can be accompanied with other musculoskeletal or vascular complications, making the management and recovery even more problematic.

The epidemiological statistics also show that males have a higher incidence rate of multi-ligament knee injury in comparison to females mainly because they have a high rate of involvement in contact sports and other risky physical activities(Dubé et al., 2024). But as the number of female athletes participating in competitive sports has increased, recent research has been showing an increasing trend in the number of ligament injuries in female athletes. The importance of early diagnosis and recognition of MLKIs is essential and timely treatments can prevent chronic knee instability, worse functional

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Volume 11, Issue 2 Mar - Apr 2026, pp: 1105-1120 www.ijprajournal.com ISSN: 2456-4494

performance, and risk of degenerative joint diseases like osteoarthritis. Knowledge of the epidemiology of multi-ligament knee injuries is thus significant towards the enhancement of preventative measures, clinical management as well as future studies in orthopedic and sports medicine.

Mechanisms of Injury

Multi-ligament knee injury is a condition in which the knee joint is exposed to an excess of mechanical forces causing simultaneous damage to two or more of the stabilizing structures of the knee joint including anterior cruciate ligament (ACL), posterior cruciate ligament (PCL), medial collateral ligament (MCL) and meniscus. The injuries are usually characterized by high-energy trauma or acute biomechanical stress surpassing the structural integrity of the ligaments and other tissues. Due to the central location of the knee joint in the weight-bearing and dynamic movement, it is especially susceptible to forces caused by the sport or accident, as well as the abrupt alterations in body movement(Morsi et al., 2025).

A twisting or rotating movement of the knee with foot planted on the ground is one of the most frequent injury mechanisms(Li et al., 2019). Such a movement is common in games that demand swift alterations of direction or pivoting or leaping like football, basketball, or soccer. The force of rotation during such movements can lead to abnormal movements of the tibia in relation to the femur and expose the ACL and menisci to excessive stress. With a strong force, there is a possibility of other structures, like the MCL, being injured as well, leading to a complex multi-ligament injury.

The other important mechanism is the direct or high-energy injury of the knee joint. To illustrate, a powerful impact on the anterior part of tibia with the knee bent, also known as a dashboard injury in road traffic accidents, may cause the tibia to be pushed backward leading to PCL injury. On the same note, a blow to the side of the knee may cause the knee to move inwards causing a lot of strain to the MCL and possibly more rupture to the ligament. Multiple ligament tears may also occur because of overstretching of the stabilizing structures of the joint in hyperextension injuries where the knee is forced to move beyond its normal range of movement(L. Zhang et al., 2020).

Multi-ligament knee injuries in most instances are a resultant combination of these mechanisms, with rotational, direct impact, and abnormal joint positioning taking place concomitant to each other. Symptoms such as severe pain, swelling, joint instability and inability to bear weight on the side of the injury are immediate symptoms of such injuries(Sim et al., 2025). The knowledge of the mechanisms of injury is significant to both clinicians and rehabilitation specialists as it aids to make the correct diagnosis, proper treatment planning, and preventive strategies to decrease the probability of such injuries in the physically active population.

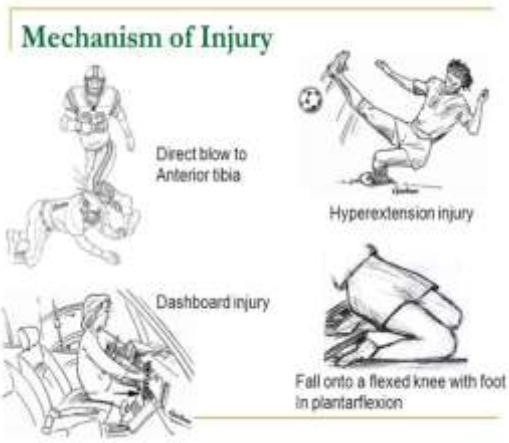

Figure 2: Common Mechanisms Leading to Multi-Ligament Knee Injuries

Table 2: Classification of Ligament Injury Severity

Grade	Description	Clinical Characteristics
Grade I	Mild ligament sprain	Minor stretching of ligament fibers with minimal instability
Grade II	Partial tear	Moderate pain, swelling, and some joint instability
Grade III	Complete tear	Severe instability, significant pain and swelling, often requires surgical intervention

Clinical Presentation and Diagnosis

Multi-ligament knee injuries are usually characterized by serious clinical manifestations because of the participation of multiple stabilizing structures of the knee joint. History of high-impact trauma, sports-related injury or abrupt twisting of the knee is common among patients at the time of injury(Ng et al., 2020). A sudden popping sensation in the knee, followed by immediate pain and swelling is one of the most commonly described

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Volume 11, Issue 2 Mar - Apr 2026, pp: 1105-1120 www.ijprajournal.com ISSN: 2456-4494

symptoms. It is usually caused by internal bleeding in the joint space, a phenomenon called hemarthrosis. Patients having such injuries might also have the problem of not being able to bear weight on the affected limb, a decrease in range of movement, and a sense of instability or the knee giving way when moving.

The swelling, and tenderness in the area of the joint, and joint stiffness are seen in most cases in the short run of the injury. Mechanical symptoms of the knee can also be reported by patients and they can be a result of locking or catching of the knee, which is possible with the involvement of the meniscus. Symptoms are usually determined by the extent of structures that are involved. Due to the involvement of several ligaments that provide stability to the knees, the damage of several ligaments may result in significant instability and dysfunctional conditions, and individuals may not be able to perform normal everyday tasks(Mahmoud et al., 2021).

A careful patient history and full physical examination are the starting points of clinical diagnosis. Physical examination involves certain orthopedic tests that are done to ascertain the integrity of various ligaments(Salik et al., 2020). Lachman test, anterior drawer test, and the posterior drawer test are tests that are usually conducted to evaluate the anterior cruciate ligament (ACL), and the posterior cruciate ligament (PCL). The medial collateral ligament (MCL) is evaluated with the valgus stress test and a range of meniscal tests including the McMurray test can be used to detect meniscal injuries. These clinical tests are used to identify the existence and extent of damage to the ligament.

Imaging techniques are also important besides physical examination to ensure the diagnosis and the level of injury. Magnetic resonance imaging (MRI) is believed to be the gold standard in assessing knee soft tissue injuries due to its ability to give a detailed image of the ligaments, menisci, cartilage, and the surrounding structures(Grover et al., 2015). X-rays also can be conducted to exclude fractures or injuries related to the bones due to trauma. The arthroscopy can be done as a diagnostic and therapeutic procedure in some cases where it will enable the internal structures of the knee joint to be directly viewed.

Early and precise diagnosis of multi-ligament knee injuries is an important factor in formulating a correct treatment strategy and avoiding the long-term effects of chronic instability, cartilage rupture and premature onset of osteoarthritis. Early detection of the damaged structures will enable clinicians to tell whether the damaged structures require conservative management or surgical intervention to ensure maximum recovery(Pais et al., 2025).

Physical Examination

Physical examination plays a vital role in clinical assessment of multi-ligament knee injuries; it aids clinicians in determining the damaged structures and the level of damage of the ligament. The test is usually started with the general examination of the injured knee where the doctor looks to see whether there is any swelling, bruising, deformity or abnormal alignment of the joint. Patients who have severe injuries to the ligaments usually have joint effusion, pain and tenderness around the knee, and restricted range of motion owing to pain and inflammation(Sobrado, 2019). Knee palpation is done to determine the presence of tenderness in the ligament attachments, joint line, and the soft tissues around the joint and this might suggest the presence of ligament or meniscal injury.

After inspection and palpation, the next stage of the examination is conducted with the help of a number of special orthopedic tests that help to assess the stability of the knee and identify the damaged ligaments. To test the integrity of the anterior cruciate ligament (ACL) by evaluating the forward motion of the tibia in relation to the femur, the Lachman test and the anterior drawer test are usually performed(Salik et al., 2020). In the evaluation of the posterior cruciate ligament (PCL), the posterior drawer test is conducted to note whether there is excessive back motion of the tibia or not. Valgus stress test, wherein medial joint stability is determined by applying a controlled inward force on the knee is tested on the medial collateral ligament (MCL). Likewise, varus stress test can also be conducted to examine lateral collateral ligament (LCL).

Besides ligament-specific tests, clinicians can also do meniscal tests like the McMurray test or Thessaly test to assess potential meniscal tears. Such tests include controlled rotational knee movements that help identify pain, clicking or locking feelings which can be a sign of meniscus damage. Since multi-ligament injuries can cause a lot of pain and muscle guarding, sometimes it is not an easy task to conduct a full physical examination right after the injury. Repeated examination in case of such cases after swelling and pain are long gone may give more accurate results(Choon & Muzaffar, 2020).

In general, physical examination is critical

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in the preliminary diagnosis of complicated knee injuries and in directing subsequent imaging tests like magnetic resonance imaging (MRI)(Jadidi et al., 2024). Proper clinical examination will enable the medical team to ascertain the degree of ligament rupture and establish a proper medical care and recovery regimen that focuses on restoring knee stability and functionality.

Imaging Techniques (MRI, X-ray, Arthroscopy)

The imaging techniques play a significant role in the diagnosis and evaluation of multi-ligament knee injuries because they provide detailed information concerning the inner organs of the knee joint not fully assessed with the assistance of the physical examination. In cases where different ligaments, and other tissues are suspected to be torn, imaging aids in the diagnosis of the injury, the degree of injury, and an appropriate treatment schedule. The most common imaging modalities in the evaluation of knee injuries are X-rays, magnetic resonance (MRI), and arthroscopy(Grover et al., 2015).

Normally X-rays are the first imaging method used in the examination of knee trauma. Unlike in the production of clear images of soft tissues such as ligaments and menisci, X-rays can be used in the identification of a fracture, bone displacement or misalignment of the joint which may be as a result of some trauma(Verhulst & MacDonald, 2020). X-rays may assist in the detection of avulsion fracture, a condition in which a ligament tears a tiny piece of bone off of its point of attachment. Therefore, X-ray imaging is more likely to be the first diagnostic method employed to rule-out bone-related injuries prior to more complicated imaging.

Magnetic resonance imaging (MRI) is the gold mark of diagnosis of knee joint soft tissue injuries. MRI is a procedure that uses a high intensity of magnetic field and radio wave to develop a clear picture of the ligaments, cartilage, menisci and tendons in the knee among other soft tissue structures. This imaging method is very sensitive and enables clinicians to definitively diagnose the tears in the ACL, PCL, MCL and menisci, and other related injuries like cartilage rupture, bone bruising or joint effusion(Sanchez-Munoz et al., 2023). MRI is said to be the most suitable way of diagnosing the conclusion of multi-ligament knee injury and in the process of deciding the surgery or conservative therapy due to its ability to provide a detailed image of the internal structures of the knee.

Another significant method is arthroscopy, which could be applied to diagnose and treat. It is a surgical process that is less invasive whereby a small instrument called an arthroscope is put into the knee joint using a small opening. The camera allows the surgeons to see the inside structures of the knee on a screen and the camera provides them a very accurate analysis of the ligament and meniscal tears. In addition to identifying the extent of damage, arthroscopy also enables the same procedure to be performed by the surgeons to perform other surgeries such as ligament repair, meniscal repair or removal. Arthroscopy is therefore often considered to be a necessity to intervene surgically to restore stability and functioning to the knee(Miclăuș et al., 2019).

Combined, these visual aids give valuable insights that can guide healthcare providers to properly diagnose multi-ligament knee injuries and design effective treatment and rehabilitation plans to achieve optimal patient recovery.

Management Strategies

Multi-ligament knee injuries require a complicated and personalized method on how they are handled due to the complexity of the structures affected and the extent of functional impairment that goes with such injuries. The goal of the treatment strategies is to achieve joint stability, pain alleviation, functional mobility, and prevent long-term complications like chronic instability and degenerative joint disease(Levy et al., 2009). The treatment depends on many factors including the amount of damaged ligaments, the severity of the trauma, the age of the patient, his or her activity, the health condition in general, and the presence of other injuries, including meniscal tears or cartilage ruptures.

The initial management is normally directed towards pain relief and inflammation and the prevention of additional damage to the damaged knee. This phase may include rest, immobilization of the joint with a brace, or knee support, ice to reduce swelling, compression and elevation of the injured leg. This technique can also be referred to as the RICE protocol (Rest, Ice, Compression, and Elevation) and it will be possible to control the acute symptoms and prepare the knee to receive further treatment(Hsu et al., 2019). There might also be the use of nonsteroidal anti-inflammatory drugs (NSAIDs) as a type of pain management on medical advice.

After the acute stage, the management can be continued with either conservative treatment or surgery based on the injury severity and complexity. The mild-moderate ligament ruptures

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or the instances where the knee joint is relatively stable are normally treated conservatively. The main methods in this approach are organized physiotherapy which aims at strengthening the muscles around, enhancing stability of the joints and recovery of range of motion. The rehabilitation exercises will help strengthen the hamstring and quadriceps, increase balance and proprioception and slowly revert the patient to the normal functioning activities(Rodriguez et al., 2021).

Surgical reconstruction might be necessary in more serious instances, especially in cases where more than one ligament is fully torn, or in cases where the knee joint is not stable. Surgery tries to correct or restore the damaged ligaments with the help of the own tissue grafts or donor tissue grafts. Moreover, meniscal injuries can be treated by repairing or excising the damaged part of the meniscus. Postoperative rehabilitation is an important component of the rehabilitation process and must be monitored with strict physiotherapy to restore the strength, elasticity and stability of the knee joint(Elkin et al., 2019).

Overall, the management of multi-ligament knee injuries must be multidisciplinary, and include orthopedic surgeons, physiotherapists, and rehabilitation specialists(Sidharthan& Bhattacharya, 2024). It is necessary that early diagnosis, proper choice of treatment and following a planned rehabilitation program should lead to best possible functional recovery and people should be able to resume their daily activities and physical performances.

Conservative Treatment

Certain knee ligament injuries in which the damage is partial wherein the joint is relatively stable or where surgery is not urgently needed are also said to be conservative treated. The main aim of the conservative approach is to alleviate pain and inflammation, recreate the functional stability of the knee, enhance the range of motion and muscle strength of the patient using non-surgical procedures(Stone et al., 2021). This treatment is usually suggested in case of mild to moderate injuries or isolated ligament ruptures or when a patient has a lifestyle or medical history that might not allow surgery.

Conservative management is the first stage that aims at containing the acute symptoms and avoiding additional harm to the damaged structures. This stage often involves rest, and activity adjustment to eliminate movements that subject the knee joint to undue pressure. RICE protocol of Rest, Ice, Compression, and Elevation is normally used to decrease swelling and inflammation in the initial stages after an injury(Lim & Al-Dadah, 2022). Knee braces or supportive bandages could also be prescribed to stabilize the joint and restrict unnecessary movement during the recovery period. Moreover, nonsteroidal anti-inflammatory medications (NSAIDs) can be prescribed with a medical recommendation to aid in pain and inflammation management.

Once the acute symptoms start to diminish, conservative treatment including rehabilitation by means of physiotherapy becomes a focus. The goal of physiotherapy programs is to restore the joint mobility, strengthen the muscles around it and enhance functional stability of the knee gradually. Knee-cap muscle exercises to strengthen the quadriceps, hamstring and calf muscles serve to provide further support to the knee joint and to counteract the weakness of the ligaments(Kirkby Shaw et al., 2020). Flexibility and range-of-motion exercises are also presented to avoid stiffness and enhance joint mobility.

Along with muscle strengthening, balance and proprioception training is a common part of rehabilitation programs that help to enhance coordination and awareness of the joints during movement. Such exercises would be relevant in minimizing the chances of re-injury and improved overall knee stability in daily tasks and physical performance(Erdemir et al., 2019). The rehabilitation exercises are progressively followed to make sure that the patient is able to resume normal functioning gradually without undue stress on the healing structures.

On the whole, conservative treatment is a significant part of the treatment of some knee ligament injuries, especially those that are not so severe that they may need to be reconstructed. Non-surgical management of knee function, stability and mobility can help many patients who have appropriate rehabilitation and follow medical advice to improve their knee condition significantly.

Surgical Reconstruction

Surgical reconstruction may be advised in severe multi-ligament knee injuries in situations where both or one of the ligaments are completely torn, joint is not stable or where the conservative treatment fails to reestablish normal knee function. The main aim of surgical reconstruction is to repair or reconstruct the damaged ligaments to restore structural integrity and biomechanical stability of the knee joint. This method is especially relevant in

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physically active or sporty persons since untreated ligament rupture may result in chronic instability, additional damage to meniscus or cartilage, and degenerative diseases in the long term, such as osteoarthritis(Sleem et al., 2025).

Ligament repair is generally an operation that enhances the damaged ligament with a graft that serves as a framework in the growth and incorporation of new tissues of the ligament with the surrounding structures. The graft to be used in reconstruction may be an autograft, or an allograft, which is obtained either in the body of the patient, the autograft, or a donor, the allograft. Usual sources of autografts are patellar tendon, hamstring tendon, or quadriceps tendon. In the process, tunnels are made in the femur and tibia and the graft is then placed and fixed in place to imitate the normal position and functioning of the original ligament(J. K. Monson et al., 2022). The graft is subjected to a biological process called ligamentization and over time it is slowly converted into tissue which operates like a natural ligament.

Surgical management in multi-ligament knee injuries can be either by reconstruction of more than one ligament during a single operation or by a series of operation according to the injury severity and the general state of knee. Related injuries like meniscal tears can also be treated during the surgery process by repairing or partial excising damaged meniscal tissue(von Rehlingen-Prinz et al., 2024). The development of arthroscopes in surgery has greatly enhanced the accuracy and success of ligament reconstruction surgery at a minimal trauma and recovery costs.

After surgery, a rehabilitation program should be structured so as to have optimum recovery. The rehabilitation after the operations is aimed at regaining the range of motion, strengthening of muscles around the area of operation, enhancing the joint stability, and slowly restoring the normal physical activities of the patient. The rehabilitation process is most often progressive and can take months before the individual is fully functional. Through effective surgical reconstruction and adequate rehabilitation, knee stability, pain and physical activity may greatly enhance, enabling individuals to restore to their former physical activity level(J. Monson et al., 2022).

Rehabilitation Protocols

Recovery after a multi-ligament knee injury—regardless of whether it is conservatively managed or surgically reconstructed—rests on rehabilitation to restore knee function, joint stability, muscle strength, and return to normal daily activities and performance in a gradual manner(Samuel et al., 2019). Given that multi-ligament injuries result in substantial damage to the stabilizers of the knee, rehabilitation should follow an organized and progressive protocol to minimize the risk of re-injury while optimizing the healing process.

The initial phase of rehabilitation involves protecting the healing structures of the knee and reducing edema. Patients are often instructed to restrict weight bearing and to use assistive devices, such as crutches or knee braces, when they begin rehabilitation in order to stabilize their knee. Gentle range-of-motion exercises will be initiated early to minimize stiffness at the joint and to maintain mobility, while not overloading the healing ligaments. Pain and swelling will be managed using modalities such as cryotherapy, compression and elevation(Ruffault et al., 2024).

As progression of the healing process takes place, the rehabilitation program will progress toward strengthening the muscles that surround the knee joint (quadriceps, hamstrings and calf muscles), which will provide additional support and stability at the knee and compensate for ligamentous weakness during recovery(Haidar et al., 2025). Strengthening exercises (e.g., straight leg raises, hamstring curls and controlled resistance training) will be used to improve the strength and endurance of these muscle groups.

Balance, coordination and proprioceptive training will be emphasized in the later stages of rehabilitation to restore proprioceptive ability (the body's awareness of where it is in space).

Table 3: Phases of Rehabilitation After Knee Ligament Injury

Rehabilitation Phase	Rehabilitation Phase	Rehabilitation Phase
Phase 1: Acute Phase	Reduce pain and swelling	Rest, ice therapy, compression, limited weight bearing
Phase 2: Early Rehabilitation	Restore range of motion	Gentle mobility exercises and physiotherapy
Phase 3: Strengthening Phase	Improve muscle strength	Quadriceps and hamstring strengthening

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		exercises
Phase 4: Functional Training	Restore coordination and stability	Balance training and proprioceptive exercises
Phase 5: Return to Sport	Prepare for athletic activity	Sport-specific drills and gradual return to play

Complications and Long-Term Outcomes

Multi-ligament knee injuries are very complicated injuries that, if not diagnosed correctly or managed appropriately, may lead to various complications. In multi-ligament knee injuries, the multiple stabilizing structures in the knee joint are damaged, therefore the long-term risk of functional impairment is much higher than in isolated ligament injuries. Chronic instability, due to misalignment of the ligaments with respect to their anatomical positions, is one of the most common complications associated with multi-ligament injuries(Z. Zhang & Li, 2023). It creates mechanical instability of the knee joint and adversely affects normal patterns of movement (walking, running, going up and down stairs) and predisposes the patient to reinjury of the knee.

Other potential problems that may contribute to chronic instability include joint stiffness, decreased range of motion and muscle weakness. Stiffness and decreased range of motion are common complications after multi-ligament injuries; they can occur as a result of prolonged immobilization, scar formation, or inadequate rehabilitation. Patients may have difficulty with full flexion or extension of the knee, disrupting their regular daily activities and physical performance(Hauser et al., 2024). Furthermore, many patients experience muscle weakness, particularly in the quadriceps and hamstring muscles, due to the decreased use of the injured limb during the recovery period.

Meniscus and articular cartilage injury are also significant problems with multi-ligament injuries. Cartilage and meniscal injuries reduce or eliminate the protective buoyancy of the knee joint, leading to increased friction between the bones(Figueroa et al., 2024). Over time, this creates a progressive degeneration of joint surfaces and ultimately, the evolution of osteoarthritis, a chronic degenerative condition characterized by pain, stiffness, swelling, and decreased mobility of the joint.

Case Reflection: Personal Experience with Multi-Ligament Knee Injury

Experiencing a multi-ligament knee injury occurred during my competitive badminton match. Badminton involves many activities such as jumping, lunging, changing directions quickly, and sprinting then instantly stopping. I sustained an injury in this instance by twisting my knee awkwardly while my foot remained on the ground. Additionally, I experienced immediate pain and instability to my left knee. After immediate injury onset, I developed considerable swelling and then had difficulty putting weight on my left leg and feeling as if my knee could no longer allow me to move normally.

When I had my initial medical evaluation, I found out from my doctor the extent of my injury based upon a physical exam and magnet resonance imaging (MRI). My MRI revealed that I had injured many of the stabilizing components in my knee: the anterior cruciate ligament (ACL), posterior cruciate ligament (PCL), medial collateral ligament (MCL), and meniscus. The combined injury of these ligaments was considered a multi-ligament knee injury, resulting in substantial loss of stability and functional capability to my knee. When I first sustained my injury, I received treatment for pain and swelling, and aggravating my present condition; therefore, treatment was limited to rest, immobilization, or chronic pain management.

As I continued to recover from my injury, physiotherapy and rehabilitation (PT and rehab) were essential to my treatment plan. A formal, structured rehabilitation program developed to achieve multiple goals. The goals and objectives of physical therapy and reconditioning were to return the range of motion in the affected area of the knee joint, rebuild the strength of surrounding muscles, and regain stability.

II. DISCUSSION

Multi-ligament knee injuries are a complicated clinical issue involving numerous supporting structures that help preserve the knee's functional stability combined in a single disorder. Injuries that impact the ACL, PCL, MCL, and meniscus severely impair the biomechanical security of the knee and frequently result in significant functional limitations. Multi-ligament knee injury responses are generally caused by high-energy trauma and include sports-related activities involving abrupt twisting, abrupt directional changes, or excessive loads applied to the knee

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joint(Baeza et al., 2024). As it was discussed throughout the previous sections; concurrent injury of these supporting structures may produce instability, pain, and persistent clinical complications if proper management and intervention do not occur.

Multi-ligament knee injuries necessitate an extensive examination and diagnosis that includes a thorough patient history, physical examination, and advanced imaging studies. Diagnostic procedures, such as the Lachman test, posterior drawer test, and valgus stress test, provide valuable information regarding the integrity of individual ligaments(Morsi et al., 2025). However, MRI is also an essential tool for determining the exact level of injury/extent of damage to both the ligaments and meniscus. Accurate and early diagnosis is an essential component to developing an effective treatment plan and avoiding further deterioration of the joint.

Management of multi-ligament knee injuries will vary depending on the degree of injury to the individual ligaments and the specific ligaments compromised in the injury. When there is partial damage to ligaments and adequate stability of the joint can be maintained through rehabilitation and progressive strengthening of the musculature, non-operative treatment options may be appropriate. However, severe injuries involving complete failures of the ligaments are typically managed with surgical reconstruction or repair to restore the functional capacity of the knee(Hsu et al., 2019).

Future Directions in Treatment and Research

Improvements in both sports medicine and medical technology have made tremendous gains in diagnosis and management of multi-ligament knee injuries; however, ongoing research continues to find ways to best treat and rehabilitate individuals with multi-ligament knee injuries. Exploring the best way to manage complex knee injuries will primarily focus upon improving surgical techniques, enhancing rehabilitation protocols, and developing preventive programs to reduce the number of complex knee injuries, as well as mitigate the long-term effects of the injury for both athlete and physically active individuals(Amirouche & Patel, 2025).

Development of better surgical reconstruction techniques and graft materials is currently an important focus of research. Researchers are looking at advances in the use of arthroscopy, biologically enhanced grafts, and tissue engineering as a way to help the ligament heal and integrate. Use of biologic therapies such as platelet-rich plasma (PRP) and stem cells are also being investigated to accelerate tissue regeneration and improve the healing process following ligament reconstruction(Chen et al., 2023). Use of these new therapies may significantly improve recovery time, increase the strength of the reconstructed ligaments, and help to minimize the complications associated with traditional surgical techniques.

Another area of development with regard to treatment is how to optimize rehabilitation protocols. Increasingly, rehabilitation programs are utilizing advanced physiotherapy techniques, neuromuscular training, and sport-specific conditioning as key components of their rehabilitation programs to improve the functional outcomes and reduce re-injury rates. Use of motion analysis technology, wearable sensors, and biomechanical assessments can assist rehabilitation professionals to better identify movement patterns and design individualized rehabilitation programs specific to each patient. These particular advancements will predominantly benefit those athletes who are returning to sport, thus requiring a safe and efficient opportunity to do so(Hemphill et al., 2020).

III. CONCLUSION

Multi-ligament knee injuries that include anterior cruciate ligament (ACL), posterior cruciate ligament (PCL), medial collateral ligament (MCL), and the meniscus are some of the most complicated knee joint injuries. Such traumas undermine the stability, biomechanics and functional capacity of the knee greatly and tend to result in pain, loss of mobility and complicated complications in the long term unless they are well addressed. Since knee joint is a crucial part of daily life and sport activity, the injuries that involve various stabilizing structures should be thoroughly assessed and managed.

The present review points to the anatomical significance of major ligaments and menisci to provide knee stability and the prevalent mechanisms that lead to multi-ligament injuries. Clinical examination and imaging, including magnetic resonance imaging (MRI), are critical in the precise diagnosis of the extent of the liver of ligament and meniscal damage. When the disease is diagnosed early, the healthcare providers can resolve the most suitable treatment method whether conservative or surgical reconstruction.

Multi-ligament knee injuries can be

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Volume 11, Issue 2 Mar - Apr 2026, pp: 1105-1120 www.ijprajournal.com ISSN: 2456-4494

treated effectively by employing a multidisciplinary approach, which incorporates the use of orthopedic intervention, systematic physiotherapy, and long-term rehabilitation. Strength, flexibility, balance, and neuromuscular control rehabilitation protocols are an important aspect in restoring joint stability and functional movement. In the case of athletes and physically active individuals, rehabilitation is especially critical in facilitating a safe redefinition to sports with the least risk of re-injury.

The subjective analysis made in this review also highlights the practical effects of this form of injury on the athletes, especially in the sports that demand quick shifts in direction and great degrees of bodily coordination such as badminton. The personal experience of the injury emphasizes the significance of proper management of the injury, patient adherence to the rehabilitation process, and the level of prevention knowledge.

To sum up, the timely diagnosis, proper treatment planning, and compliance with the organized rehabilitation plans are the keys to the successful recovery process in the multi-ligament knee injuries victims. Further studies and surgical procedures, rehabilitation approaches and injury prevention measures will further improve the management and long-term prognosis of these challenging orthopedic diseases.

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