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Current Concepts in Medial Patellofemoral Ligament Reconstruction: Biomechanics, Graft Selection, and Surgical Strategies

Mohamed Abdallah ElSofy, Mohamed Hamed Fahmy, Mohamed Saeed ElAttar, Mohamed Akmal Diab

Orthopedic Surgery Department, Faculty of Medicine, Zagazig University
Corresponding author: Mohamed Akmal Diab

ABSTRACT

***Background*:** Recurrent patellar instability is a common orthopedic condition that primarily affects adolescents and young adults, particularly those engaged in athletic activities. Injury to the medial patellofemoral ligament (MPFL) is present in the majority of acute lateral patellar dislocations and represents a key factor contributing to recurrent instability. The MPFL functions as the primary passive restraint against lateral displacement of the patella during the early phases of knee flexion. Over the past two decades, advances in anatomical and biomechanical understanding of the patellofemoral joint have led to the widespread adoption of MPFL reconstruction as the preferred surgical treatment for patients with recurrent patellar dislocation. Numerous surgical techniques and graft options have been described with the aim of restoring normal patellar tracking and improving functional outcomes.

Aim: This review aims to summarize the current concepts in medial patellofemoral ligament reconstruction, focusing on the anatomical and biomechanical principles underlying patellar stability, the indications for surgical intervention, and the various graft options and surgical techniques currently utilized. Additionally, this article examines fixation strategies, technical considerations during reconstruction, potential complications, and reported clinical outcomes associated with different reconstructive approaches.

Conclusion: MPFL reconstruction has demonstrated reliable clinical outcomes in restoring patellar stability and reducing recurrence rates in patients with recurrent patellar instability. A thorough understanding of patellofemoral anatomy, biomechanics, and individual patient risk factors is essential for optimal surgical planning. Various graft options, including hamstring tendons and quadriceps tendon autografts, have shown favorable results when used in anatomical reconstruction techniques. Accurate femoral tunnel placement, appropriate graft tensioning, and individualized surgical strategies remain critical factors influencing successful outcomes. Continued research and long-term clinical studies are required to refine surgical techniques and further optimize the management of patellofemoral instability.

Keywords: Medial Patellofemoral Ligament Reconstruction, Graft Selection, and Surgical Strategies

INTRODUCTION

Patellar instability represents a common disorder of the knee joint that frequently affects adolescents and young adults, particularly individuals involved in athletic activities requiring rapid changes in direction or pivoting movements. Acute lateral patellar dislocation is often the initial presentation and may lead to recurrent instability if the underlying pathological factors are not adequately addressed. Epidemiological studies have reported an incidence of primary patellar dislocation ranging from approximately 5 to 7 cases per 100,000 individuals annually, with significantly higher rates observed among adolescent populations. Recurrent instability following an initial dislocation occurs in a substantial proportion of patients and may lead to chronic pain, functional limitations, and progressive damage to the patellofemoral articular cartilage. Consequently, early recognition and appropriate management of patellar instability are essential to prevent long-term joint deterioration. [1,2]

The medial patellofemoral ligament (MPFL) has been identified as the primary passive restraint preventing lateral translation of the patella during the early stages of knee flexion. Anatomical and biomechanical studies have demonstrated that the MPFL contributes approximately 50–60% of the restraining force against lateral patellar displacement when the knee is between full extension and 30 degrees of flexion. Injury to this ligament occurs in the majority of acute lateral patellar dislocations and is therefore considered a central factor in the pathophysiology of recurrent patellar instability. Restoration of the MPFL has thus become a key focus in surgical treatment strategies aimed at reestablishing normal patellofemoral biomechanics. [3,4]

Historically, surgical management of patellar instability involved various soft-tissue realignment procedures such as medial reefing, lateral retinacular release, and distal realignment techniques. Although these procedures were intended to correct patellar maltracking, many of them failed to reproduce the native biomechanics of the patellofemoral joint and were associated with inconsistent clinical outcomes. Over the past two decades, improved understanding of the anatomical structure and biomechanical function of the MPFL has led to a paradigm shift toward anatomical reconstruction of this ligament. MPFL reconstruction has consequently become the cornerstone surgical procedure for patients with recurrent patellar instability in the absence of major bony abnormalities requiring additional corrective procedures. [5,6]

Numerous surgical techniques have been developed for MPFL reconstruction, reflecting the ongoing effort to restore the native anatomy and function of the ligament. These techniques vary in terms of graft selection, fixation methods, and surgical approach. Commonly used graft options include hamstring tendons such as the semitendinosus or gracilis, quadriceps tendon autografts, adductor magnus tendon grafts, and allograft tissues. Each graft option possesses unique biomechanical properties and surgical considerations, which may influence the stability of the reconstructed ligament as well as the risk of complications. As a result, graft selection remains an important topic of discussion among orthopedic surgeons specializing in patellofemoral surgery. [7]

In addition to graft choice, several technical factors play a critical role in determining the success of MPFL reconstruction. Accurate identification of the anatomical femoral attachment site, appropriate graft tensioning, and restoration of normal patellar tracking are essential for achieving optimal outcomes. Malposition of the femoral tunnel, excessive graft tension, or failure to address associated anatomical abnormalities may result in persistent instability, graft failure, or abnormal patellofemoral joint loading. Therefore, a comprehensive understanding of patellofemoral biomechanics and individualized surgical planning are crucial elements in modern MPFL reconstruction strategies. [8]

Despite the increasing popularity of MPFL reconstruction and the growing body of literature describing various surgical techniques, considerable variability still exists regarding optimal graft selection and surgical approach. Furthermore, evolving evidence continues to refine current surgical strategies and highlight factors that may influence postoperative outcomes. Therefore, the purpose of this review is to summarize the current concepts in medial patellofemoral ligament reconstruction, focusing on the biomechanical principles underlying patellar stability, the available graft options, and the surgical strategies currently employed to restore patellofemoral joint stability in patients with recurrent patellar instability.

Anatomy of the Medial Patellofemoral Ligament

A detailed understanding of the anatomical structure of the medial patellofemoral ligament (MPFL) is essential for performing successful reconstruction procedures and restoring normal patellofemoral biomechanics. The MPFL is a key component of the medial soft-tissue stabilizing complex of the knee and plays a crucial role in preventing lateral displacement of the patella.

Anatomical studies have demonstrated that the MPFL extends from the superomedial border of the patella to its femoral attachment located between the medial epicondyle and the adductor tubercle. This ligament forms part of the medial retinacular structures and functions as the primary passive stabilizer resisting lateral patellar translation during the early phases of knee flexion. Understanding the precise anatomical relationships of the MPFL is critical in reconstructive surgery to ensure accurate graft placement and restoration of physiological patellar tracking. [9,10]

The femoral attachment of the MPFL is considered one of the most important anatomical landmarks during reconstruction procedures. Several anatomical and radiographic studies have identified the femoral origin as a point located between the medial epicondyle and the adductor tubercle, commonly referred to as the "Schöttle point." This location has become widely accepted as the optimal site for femoral tunnel placement during MPFL reconstruction. Accurate identification of this anatomical landmark is essential because even small deviations from the native femoral insertion can significantly alter graft length changes during knee motion. Malposition of the femoral tunnel may result in graft overtensioning, patellar overconstraint, or persistent instability. Therefore, intraoperative fluoroscopy or precise anatomical palpation is often used to ensure correct tunnel positioning. [11,12]

On the patellar side, the MPFL inserts along the proximal two-thirds of the medial border of the patella. The patellar attachment is broad and fan-shaped, blending with the medial retinaculum and adjacent soft-tissue structures. This wide insertion allows the MPFL to distribute forces across the medial patellar surface and contributes to the stability of the patellofemoral joint during knee motion. During reconstruction procedures, surgeons often replicate this anatomical configuration by placing graft fixation points along the superomedial border of the patella. Some surgical techniques utilize patellar bone tunnels or suture anchors, while others preserve the natural patellar insertion by using quadriceps tendon–based grafts. Replicating the native patellar insertion site is important for maintaining physiological patellar tracking and preventing abnormal joint loading. [13]

The MPFL is closely associated with other structures within the medial retinacular complex, including the medial patellotibial ligament and the medial patellomeniscal ligament. Together, these structures contribute to the dynamic stabilization of the patella throughout the range of knee motion. Additionally, the vastus medialis obliquus (VMO) muscle fibers are intimately related to the proximal portion of the MPFL and provide dynamic medial support to the patella during quadriceps contraction. Injury to the MPFL often occurs near the femoral attachment during acute lateral patellar dislocation, although lesions may also occur at the patellar insertion or within the ligament substance itself. Recognition of these anatomical relationships has contributed significantly to the development of modern anatomical reconstruction techniques. [14]

The vascular supply of the MPFL is derived primarily from branches of the genicular arterial network, particularly the superior medial genicular artery. Adequate vascularization plays an important role in ligament healing and graft incorporation following reconstruction procedures. In addition, the proximity of the MPFL to important neurovascular structures emphasizes the need for careful surgical dissection during reconstruction to avoid potential complications. A thorough understanding of the anatomical features of the MPFL therefore provides the foundation for accurate surgical reconstruction and improved clinical outcomes in the treatment of recurrent patellar instability. [15]

Biomechanics of Patellofemoral Stability

Patellofemoral stability is maintained through a complex interaction of osseous geometry, soft-tissue restraints, and dynamic muscular control. Unlike hinge joints that rely primarily on bony congruity, the patellofemoral joint demonstrates limited osseous constraint during early knee motion. Consequently, soft-tissue stabilizers play a critical role in maintaining proper alignment of the patella within the trochlear groove. During the initial phases of knee flexion, the patella is not yet deeply engaged within the trochlear groove, making the medial stabilizing structures particularly important in preventing excessive lateral translation. The medial patellofemoral ligament (MPFL) acts as the primary passive restraint during this early motion phase, contributing significantly to the stabilization of the patella before bony constraints become more effective. [16,17]

The biomechanics of patellofemoral stability also depend heavily on the geometry of the femoral trochlea. As the knee flexes beyond approximately 30 degrees, the patella progressively engages within the trochlear groove, allowing the osseous architecture of the distal femur to provide increasing stability. In individuals with normal trochlear anatomy, the lateral trochlear ridge acts as a barrier that limits lateral patellar displacement. However, anatomical variations such as trochlear dysplasia may compromise this stabilizing mechanism, leaving the patella more reliant on soft-tissue restraints for stability. This interplay between osseous morphology and ligamentous support is a critical consideration when evaluating patients with recurrent patellar

instability. [18]

Dynamic muscular forces generated by the quadriceps mechanism also play an essential role in maintaining patellofemoral alignment. The quadriceps muscle group exerts both compressive and translational forces on the patella during knee extension and flexion. Among these muscles, the vastus medialis obliquus (VMO) provides a medial stabilizing vector that counteracts the lateral pull exerted by the vastus lateralis. Coordinated activation of these muscles ensures balanced patellar tracking throughout knee motion. Disruption of this muscular balance, whether due to injury, neuromuscular dysfunction, or anatomical abnormalities, may contribute to abnormal patellar tracking and increased risk of instability. [19]

Another important biomechanical factor influencing patellofemoral stability is the alignment of the extensor mechanism. The quadriceps angle (Q-angle) reflects the lateral vector applied to the patella during quadriceps contraction. Increased Q-angle values are associated with greater lateral forces acting on the patella and may predispose individuals to patellar maltracking and instability. Similarly, the position of the tibial tubercle relative to the trochlear groove influences the direction of the extensor mechanism force vector. Excessive lateralization of the tibial tubercle increases the lateral pull on the patella and may require surgical correction in addition to soft-tissue reconstruction procedures. [20]

Load distribution across the patellofemoral joint changes dynamically throughout the range of knee motion. As the knee flexes, contact areas between the patella and trochlea increase, resulting in higher compressive forces within the joint. These forces are transmitted through both the articular cartilage and surrounding soft tissues. Reconstruction of the MPFL must therefore be performed in a manner that restores stability without excessively increasing medial patellofemoral contact pressures. Improper graft tensioning or malposition of reconstruction tunnels may alter the natural biomechanics of the joint and potentially contribute to postoperative pain or cartilage degeneration. [21]

Modern biomechanical studies emphasize that successful restoration of patellofemoral stability requires a comprehensive understanding of both static and dynamic stabilizing mechanisms. The MPFL functions in coordination with surrounding structures, including the medial retinaculum, quadriceps musculature, and trochlear morphology. Therefore, surgical reconstruction strategies must aim not only to restore the ligament itself but also to respect the broader biomechanical environment of the patellofemoral joint. This integrated approach is essential for optimizing surgical outcomes and minimizing complications following MPFL reconstruction. [22]

Indications for Medial Patellofemoral Ligament Reconstruction

Appropriate patient selection is a fundamental factor in achieving successful outcomes following medial patellofemoral ligament (MPFL) reconstruction. Although many patients experience a single episode of acute patellar dislocation that can be managed conservatively, a substantial proportion develop recurrent instability that significantly affects knee function and quality of life. Recurrent lateral patellar dislocation is widely considered the primary indication for MPFL reconstruction, particularly in patients who continue to experience instability despite structured rehabilitation and conservative management. Persistent instability may lead to recurrent episodes of giving way, pain, and limitations in sports participation, making surgical stabilization necessary to restore normal patellofemoral mechanics. [23,24]

Another important indication for MPFL reconstruction is recurrent patellar subluxation without complete dislocation. These patients may report sensations of patellar shifting or apprehension during activities involving knee extension or rotational movements. Although complete dislocation may not occur, repetitive subluxation events can still lead to progressive cartilage damage and deterioration of the patellofemoral joint. In such cases, reconstruction of the MPFL can help restore medial soft-tissue restraint and improve patellar tracking, thereby preventing further joint damage and improving patient-reported outcomes. [25]

Imaging plays a crucial role in evaluating patients with patellar instability and determining the appropriateness of surgical intervention. Magnetic resonance imaging (MRI) is commonly used to confirm injury to the MPFL and to assess associated soft-tissue or osteochondral lesions. In addition, computed tomography (CT) or MRI measurements are frequently used to evaluate anatomical risk factors such as the tibial tubercle–trochlear groove (TT–TG) distance, patellar height, and trochlear morphology. Identifying these structural abnormalities is important because they may influence both the surgical strategy and the likelihood of successful reconstruction. Comprehensive preoperative imaging allows surgeons to tailor the procedure according to the individual anatomical characteristics of each patient. [26,27]

In patients with significant anatomical abnormalities, isolated MPFL reconstruction may not be sufficient to restore stability. For example, excessive lateralization of the tibial tubercle, commonly indicated by an increased TT–TG distance, may require tibial tubercle osteotomy to correct the abnormal force vector acting on the patella. Similarly, severe trochlear dysplasia may necessitate trochleoplasty in selected cases. In such situations, MPFL reconstruction is often performed in combination with these corrective procedures to address both soft-tissue and bony contributors to patellar instability. Careful preoperative planning is therefore essential in determining whether isolated ligament reconstruction or combined surgical intervention is required. [28]

Skeletal maturity is another important consideration when determining indications for MPFL reconstruction. In skeletally immature patients, care must be taken to avoid injury to the distal femoral growth plate during femoral tunnel placement. Modified surgical techniques that utilize soft-tissue fixation or physeal-sparing approaches have been developed to address this concern while still providing effective stabilization of the patella. These techniques allow safe reconstruction of the MPFL in pediatric and adolescent patients while minimizing the risk of growth disturbances. [29]

Finally, patient-specific factors such as activity level, degree of functional impairment, and expectations regarding return to sport must also be considered when determining the indication for surgery. Athletes and highly active individuals often require reliable stabilization of the patella in order to resume high-demand activities safely. MPFL reconstruction has demonstrated high rates of return to sport and significant improvements in functional scores in appropriately selected patients. Consequently, individualized assessment of clinical symptoms, anatomical risk factors, and patient goals remains essential for determining the optimal treatment strategy for patellar instability. [30]

Graft Selection in Medial Patellofemoral Ligament Reconstruction

Graft selection represents one of the most important considerations in medial patellofemoral ligament (MPFL) reconstruction, as the chosen graft must replicate the anatomical orientation, biomechanical strength, and functional behavior of the native ligament. Over the past two decades, numerous graft sources have been described in the literature, reflecting the ongoing evolution of surgical techniques aimed at restoring patellar stability. The ideal graft should provide sufficient tensile strength to resist lateral patellar displacement while maintaining appropriate elasticity to avoid overconstraint of the patellofemoral joint. Additionally, the graft should allow reliable fixation, minimal donor-site morbidity, and reproducible surgical technique. Consequently, graft choice often depends on surgeon experience, patient characteristics, and specific technical considerations associated with each reconstructive method. [31,32]

Hamstring tendon autografts remain among the most commonly utilized grafts for MPFL reconstruction. The semitendinosus and gracilis tendons are particularly popular due to their favorable biomechanical properties, adequate graft length, and ease of harvesting. These tendons possess tensile strength that exceeds that of the native MPFL, providing robust structural support for ligament reconstruction. In most surgical techniques, the harvested hamstring graft is fixed to the patella and femur using bone tunnels, suture anchors, or interference screws in order to recreate the anatomical course of the ligament. Numerous clinical studies have demonstrated satisfactory functional outcomes and low recurrence rates following MPFL reconstruction using hamstring autografts, making them a widely accepted option among orthopedic surgeons. [33]

Despite their advantages, hamstring tendon grafts are associated with certain limitations that have prompted exploration of alternative graft sources. Harvesting the semitendinosus or gracilis tendon may lead to donor-site morbidity, postoperative pain, or mild weakness in knee flexion. In addition, techniques involving patellar bone tunnels may increase the risk of complications such as patellar fracture or hardware irritation. Although these complications are relatively uncommon, they have encouraged surgeons to consider graft options that minimize patellar bone violation while still providing adequate mechanical stability for ligament reconstruction. [34]

The quadriceps tendon has emerged as a valuable alternative graft option in MPFL reconstruction due to its favorable anatomical and biomechanical characteristics. The quadriceps tendon provides a thick and durable graft that can be harvested as a partial-thickness strip while preserving its natural attachment to the superior pole of the patella. This configuration allows the graft to function as a sling that closely replicates the anatomical insertion of the native MPFL. Additionally, maintaining the patellar attachment eliminates the need for patellar bone tunnels, thereby reducing the risk of patellar fracture. Clinical studies evaluating quadriceps tendon–based MPFL reconstruction have reported encouraging results, including satisfactory knee function and low complication rates. [35]

Other graft options described in the literature include the adductor magnus tendon and various allograft tissues. The adductor

magnus tendon has been utilized in certain techniques due to its anatomical proximity to the femoral insertion of the MPFL. This approach allows reconstruction without drilling a femoral tunnel in some cases, potentially reducing surgical complexity. However, the adductor magnus technique is less commonly used and remains less extensively studied compared with hamstring or quadriceps tendon grafts. Allografts may also be considered in revision surgeries or in patients where autograft harvesting is undesirable, although concerns regarding cost, graft incorporation, and availability may limit their routine use in primary MPFL reconstruction. [36]

Ultimately, the choice of graft should be individualized based on patient anatomy, surgeon expertise, and the specific surgical technique being performed. Both hamstring and quadriceps tendon autografts have demonstrated favorable outcomes when used in anatomical reconstruction techniques. The growing body of literature comparing different graft options continues to refine surgical decision-making and guide the selection of grafts that best restore patellofemoral stability while minimizing complications. [37]

Surgical Strategies in Medial Patellofemoral Ligament Reconstruction

Successful medial patellofemoral ligament (MPFL) reconstruction depends not only on appropriate graft selection but also on meticulous surgical technique. Modern reconstruction procedures aim to reproduce the native anatomy and biomechanical behavior of the MPFL while minimizing complications and preserving patellofemoral joint mechanics. Several surgical strategies have been described, but most contemporary techniques emphasize anatomical reconstruction with precise graft positioning and secure fixation at both the patellar and femoral attachments. The primary goals of surgery are to restore medial restraint against lateral patellar displacement, maintain physiological patellar tracking throughout knee motion, and avoid excessive graft tension that could alter joint biomechanics. [38,39]

One of the most critical technical aspects of MPFL reconstruction is accurate identification of the femoral attachment site. The femoral insertion of the MPFL lies between the medial epicondyle and the adductor tubercle, a region that can be localized radiographically using the Schöttle point. Precise placement of the femoral tunnel at this anatomical location is essential because malposition can significantly affect graft length changes during knee motion. Even small deviations from the native insertion may lead to abnormal graft tensioning, resulting in either persistent patellar instability or excessive medial constraint of the patella. For this reason, many surgeons utilize intraoperative fluoroscopy or detailed anatomical landmarks to ensure accurate femoral tunnel placement. [40]

Patellar fixation methods also vary among different reconstruction techniques. Traditionally, patellar bone tunnels have been used to secure the graft along the medial border of the patella, allowing the graft to be passed through the bone and anchored in a loop configuration. This method provides strong fixation but carries a potential risk of patellar fracture, particularly if tunnels are placed too close together or in patients with smaller patellae. To address this concern, alternative fixation techniques such as suture anchors or soft-tissue fixation methods have been developed. These approaches aim to reduce stress on the patella while still maintaining secure graft attachment and appropriate graft orientation. [41]

Proper graft tensioning during MPFL reconstruction is another crucial factor influencing postoperative outcomes. The reconstructed ligament must provide sufficient medial restraint without restricting normal patellar mobility. Excessive tension may lead to increased medial patellofemoral contact pressures and anterior knee pain, whereas insufficient tension may result in persistent instability. Most surgical protocols recommend fixing the graft with the knee positioned at approximately 30 degrees of flexion, a position in which the patella begins to engage the trochlear groove and normal patellofemoral alignment can be assessed. Intraoperative evaluation of patellar tracking throughout the range of motion helps ensure that the graft is neither overly tight nor excessively lax. [42]

Anatomical reconstruction techniques aim to replicate the native orientation and insertion sites of the MPFL as closely as possible. These techniques have gained widespread acceptance due to their ability to restore more physiological patellofemoral biomechanics compared with earlier non-anatomical procedures. By respecting the natural anatomy of the ligament and carefully restoring its functional length and orientation, anatomical reconstruction techniques can provide reliable stabilization of the patella while minimizing the risk of abnormal joint loading. Advances in surgical instrumentation and imaging guidance have further improved the accuracy and reproducibility of these procedures. [43]

In recent years, several modifications of MPFL reconstruction techniques have been proposed in an effort to further optimize surgical outcomes and reduce complications. These include techniques that avoid patellar bone tunnels, utilize soft-tissue

fixation, or incorporate quadriceps tendon grafts with preserved patellar attachment. Such innovations aim to maintain adequate stability while minimizing the risk of complications associated with traditional reconstruction methods. Regardless of the specific technique employed, careful surgical planning, precise graft placement, and appropriate tensioning remain fundamental principles for achieving successful outcomes in MPFL reconstruction. [44,45]

Complications and Failure After Medial Patellofemoral Ligament Reconstruction

Although medial patellofemoral ligament (MPFL) reconstruction has demonstrated favorable clinical outcomes and high success rates in the treatment of recurrent patellar instability, complications and failures can still occur. These complications may arise from technical errors during surgery, improper patient selection, or failure to address associated anatomical abnormalities contributing to patellar instability. Recognizing the potential causes of complications is essential for improving surgical techniques and optimizing patient outcomes. Most complications reported in the literature are related to graft malposition, inappropriate graft tensioning, or fixation-related problems that alter the normal biomechanics of the patellofemoral joint. [46]

One of the most commonly reported causes of failure after MPFL reconstruction is malposition of the femoral tunnel. Accurate placement of the femoral attachment site is crucial because small deviations from the anatomical insertion can significantly alter graft length changes during knee motion. If the femoral tunnel is positioned too proximally or distally, the reconstructed ligament may become excessively tight during knee flexion or overly lax in extension. This abnormal graft behavior can lead to increased patellofemoral joint pressures, persistent instability, or early graft failure. For this reason, careful identification of the anatomical femoral insertion site using radiographic landmarks or intraoperative fluoroscopy is widely recommended. [47]

Patellar complications represent another potential concern following MPFL reconstruction. Techniques that utilize transosseous patellar tunnels may weaken the patella and increase the risk of fracture, particularly when multiple tunnels are created or when tunnels are placed too close together. Although patellar fractures remain relatively rare, they represent a serious complication that may require additional surgical intervention. To minimize this risk, alternative fixation methods such as suture anchors or quadriceps tendon–based techniques that avoid patellar drilling have been increasingly adopted in modern reconstructive procedures. [48]

Graft overtensioning is another important technical error that may negatively affect surgical outcomes. Excessive graft tension can result in overconstraint of the patella, leading to abnormal medial patellofemoral contact pressures and anterior knee pain. Overly tight graft constructs may also restrict normal patellar mobility and contribute to postoperative stiffness. Conversely, insufficient graft tension may fail to adequately stabilize the patella, resulting in persistent instability or recurrent dislocation. Achieving appropriate graft tension therefore requires careful intraoperative assessment of patellar tracking throughout the range of knee motion. [49]

Recurrent instability after MPFL reconstruction may occur when underlying anatomical abnormalities are not adequately addressed. Factors such as severe trochlear dysplasia, patella alta, or excessive lateralization of the tibial tubercle may continue to predispose the patella to lateral displacement despite successful reconstruction of the MPFL. In such cases, isolated ligament reconstruction may be insufficient, and additional corrective procedures such as tibial tubercle osteotomy or trochleoplasty may be necessary to restore normal patellofemoral alignment. Comprehensive preoperative evaluation is therefore critical for identifying patients who may require combined surgical interventions. [50]

Postoperative stiffness and limited knee range of motion have also been reported as complications following MPFL reconstruction. These issues may result from excessive graft tension, postoperative scar formation, or inadequate rehabilitation protocols. Early mobilization and structured physiotherapy programs are essential components of postoperative management to restore knee function and prevent stiffness. With appropriate surgical technique and postoperative care, the overall complication rate following MPFL reconstruction remains relatively low, and most patients achieve satisfactory functional outcomes. Nevertheless, continued refinement of surgical strategies and improved understanding of patellofemoral biomechanics remain important for minimizing complications and enhancing long-term results. [51,52]

Future Directions in Medial Patellofemoral Ligament Reconstruction

Advances in the understanding of patellofemoral joint biomechanics and surgical techniques continue to shape the future of medial patellofemoral ligament (MPFL) reconstruction. Modern surgical approaches increasingly emphasize anatomical reconstruction and individualized treatment strategies based on patient-specific anatomical characteristics. Improved imaging

techniques, including high-resolution magnetic resonance imaging and three-dimensional computed tomography, have enhanced the ability of surgeons to identify anatomical abnormalities contributing to patellar instability. These technologies facilitate more precise preoperative planning and may help guide the selection of appropriate surgical procedures, including whether isolated MPFL reconstruction or combined corrective procedures are required. [53]

Another important area of development involves improving the accuracy of graft placement during MPFL reconstruction. Malposition of the femoral tunnel remains one of the most common technical errors associated with reconstruction failure. Emerging surgical technologies, including computer-assisted navigation and intraoperative imaging guidance, have the potential to enhance the precision of femoral tunnel placement. These tools may help surgeons reproduce the anatomical insertion of the MPFL more accurately, thereby reducing the risk of graft malposition and improving postoperative patellofemoral biomechanics. Continued research into these technologies may contribute to greater consistency and reproducibility in surgical outcomes. [54]

In addition to improvements in surgical accuracy, ongoing research is also exploring novel graft materials and biologic augmentation strategies. While traditional autografts such as hamstring tendons and quadriceps tendon remain the most commonly used graft options, alternative graft sources and biologic enhancements are being investigated to improve graft incorporation and healing. The use of biologic agents such as platelet-rich plasma or growth factor–based therapies has been proposed as a means of enhancing tissue regeneration and accelerating graft integration. Although these approaches remain largely investigational, they may represent promising avenues for improving long-term outcomes following ligament reconstruction procedures. [55]

Patient-specific surgical strategies are also gaining increasing attention in the management of patellar instability. Rather than applying a uniform surgical technique to all patients, modern treatment algorithms emphasize the importance of addressing the individual anatomical risk factors present in each case. For example, patients with severe trochlear dysplasia, patella alta, or significant tibial tubercle lateralization may benefit from combined procedures in addition to MPFL reconstruction. This comprehensive approach aims to correct both soft-tissue insufficiency and structural abnormalities that contribute to instability. As diagnostic techniques continue to improve, surgeons may be better equipped to tailor surgical strategies to the unique biomechanical characteristics of each patient. [56]

Finally, long-term clinical studies and comparative research are expected to play an important role in refining surgical strategies for MPFL reconstruction. Although current evidence supports the effectiveness of several graft options and reconstruction techniques, further high-quality randomized controlled trials and long-term follow-up studies are needed to determine the optimal surgical approaches for different patient populations. Continued collaboration between clinical researchers and orthopedic surgeons will be essential for advancing the understanding of patellofemoral instability and improving the outcomes of reconstructive procedures. [57]

Conclusion

Medial patellofemoral ligament reconstruction has become a cornerstone procedure in the surgical management of recurrent patellar instability. Advances in anatomical understanding and biomechanical research have significantly improved the ability of surgeons to restore normal patellofemoral joint stability through anatomical reconstruction techniques. Recognition of the central role of the MPFL as the primary passive restraint against lateral patellar displacement has led to the development of surgical approaches that aim to replicate the native structure and function of this ligament while preserving physiological patellar tracking.

Successful outcomes following MPFL reconstruction depend on multiple factors, including accurate patient selection, careful evaluation of underlying anatomical abnormalities, appropriate graft selection, and meticulous surgical technique. Modern reconstruction strategies emphasize anatomical femoral tunnel placement, proper graft tensioning, and restoration of the native patellar insertion to achieve optimal biomechanical function. Failure to address these technical considerations may result in complications such as graft malposition, patellar overconstraint, or persistent instability.

Graft selection remains an important aspect of MPFL reconstruction, with several autograft options demonstrating favorable clinical outcomes. Hamstring tendon autografts, particularly the semitendinosus and gracilis tendons, continue to be widely used due to their biomechanical strength and versatility. At the same time, quadriceps tendon–based techniques have gained increasing popularity as they allow preservation of the patellar attachment and may reduce the risk of patellar complications associated with bone tunnel drilling. Both graft options have shown reliable results when used within anatomical reconstruction techniques.

In addition to graft selection, the importance of individualized surgical planning has become increasingly recognized. Patellar instability is often a multifactorial condition influenced by both soft-tissue insufficiency and structural abnormalities such as trochlear dysplasia, patella alta, and increased tibial tubercle–trochlear groove distance. Therefore, isolated MPFL reconstruction may not be sufficient in all cases, and combined surgical procedures may be required to address these contributing factors. Comprehensive preoperative assessment and patient-specific treatment strategies are essential for achieving optimal outcomes.

Overall, current evidence supports MPFL reconstruction as an effective and reliable procedure for restoring patellofemoral stability and improving functional outcomes in patients with recurrent patellar instability. Continued advancements in surgical techniques, imaging technologies, and biomechanical research are expected to further refine reconstructive strategies and enhance long-term clinical results. Future studies focusing on long-term outcomes and comparative evaluations of different graft options and surgical approaches will be valuable in guiding the ongoing evolution of treatment strategies for patellofemoral instability.

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