Benha Journal of Applied Sciences (BJAS) **print: ISSN 2356–9751**
Vol. (8) Issue (7) (2023), (27-36) **online: ISSN 2356–976x**
http://bjas.journals.ekb.eg

Reconstruction of Medial Patellofemoral Ligament in the Treatment of Recurrent Patellar Instability using Hamstring Autograft by Dual Patella Docking Technique: A Comparative Review

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Abstract
Background: Recurrent patellar instability is a difficult condition that frequently necessitates surgical treatment for effective management. Reconstruction of the medial patellofemoral ligament (MPFL) has become the standard surgical approach for restoring patellofemoral stability and enhancing functional results. **Objective:** The purpose of this research is to assess the early outcomes of MPFL reconstruction using hamstring autograft using the dual patella docking technique for the treatment of recurrent patellar instability. **Conclusions:** In the surgical treatment of recurrent patellar instability, MPFL reconstruction with hamstring autograft via the dual patella docking technique shows promise. The use of hamstring autograft provides sufficient strength and anatomical resemblance to the native MPFL while limiting morbidity at the donor location. The twin patella docking approach offers benefits in terms of graft attachment and tensioning, which contribute to superior outcomes.

Keywords: Patellar Instability; MPFL; Hamstring Autograft; Dual Patella Docking; Surgical Treatment.

1. Introduction

In orthopaedic practise, patellar instability, characterised by the displacement of the patella from its normal location inside the patellofemoral joint, is a major problem. After anterior cruciate ligament tears, acute traumatic patellar dislocation is the second most prevalent cause of traumatic hemarthrosis of the knee. The annual incidence of patellar dislocation for the first time has been found to range between 6 and 43 instances per 100,000 people. It primarily affects young people, notably females between 10 and 17 years old [1, 2].

Initial treatment for patellar dislocation occurring for the first time is often nonoperative and includes a brief period of immobilisation, bracing, and physical therapy. Despite these precautions, a significant proportion of patients develop recurrent instability or permanent functional restrictions, including discomfort, mechanical symptoms, and difficulty returning to sports. Therefore, surgical intervention is required to treat symptomatic recurring patellar instability [3].

Several surgical procedures have been suggested to restore patellar stability and reduce functional deficits in patients with recurring patellar instability. Reconstruction of the medial patellofemoral ligament (MPFL) has attracted substantial attention and become the preferred surgical treatment among these approaches. The MPFL is an essential passive stabiliser of the patellofemoral joint, responsible for roughly 90 percent of the medial forces that counteract and limit lateral patellar displacement in the early range of knee flexion [4, 5].

In recent years, the use of hamstring autografts for repair of the MPFL has demonstrated encouraging outcomes. In addition, a procedure known as the dual patella docking approach has been devised to achieve anatomical restoration of the MPFL while preserving the patellar and femoral insertion morphology. This approach reconstructs the MPFL using an ipsilateral hamstring autograft to provide stability and restore normal patellar tracking [6, 7].

Numerous studies have analysed the early results of MPFL repair using a hamstring autograft and the twin patella docking approach. However, a full comparison of these investigations does not exist [8, 9]. Therefore, the purpose of this research is to assess the early outcomes of MPFL reconstruction using hamstring autograft using the dual patella docking technique for the treatment of recurrent patellar instability.

2. Anatomy and Pathophysiology of Patellar Instability:

The patellofemoral joint, which is formed by the articulation of the patella (kneecap) and the femur (thigh bone), is vital to the function and stability of the knee. The patella functions as a fulcrum for the quadriceps muscle group, aiding in the transmission of forces and facilitating smooth knee movements during flexion and extension [10]**(Figure 1)**.

The patellofemoral joint is largely stabilised by a complicated interplay between static and dynamic stabilisers. The medial patellofemoral ligament (MPFL) is crucial for limiting lateral patellar displacement and preserving patellar alignment. The MPFL originates from the medial femoral condyle and inserts into the superomedial border of the patella; it serves as the principal constraint on lateral patellar movement in the early range of knee flexion (0 to 30 degrees). It contributes over ninety

stabilising mechanisms of the patellofemoral joint are disrupted or compromised. Acute traumatic patellar dislocation is a common cause of patellar instability and is typically accompanied by severe knee trauma or a forceful lateral impact to the patella. This abrupt loss of joint integrity might result in the patella's total displacement from its normal position within the trochlear groove of the femur [12].

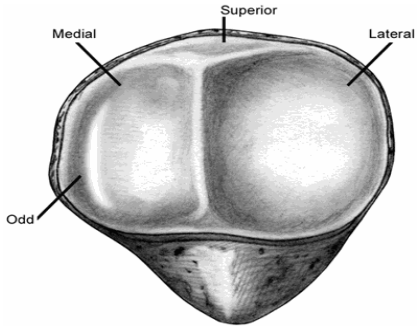

Fig. (1) Anatomy of the patella [13]

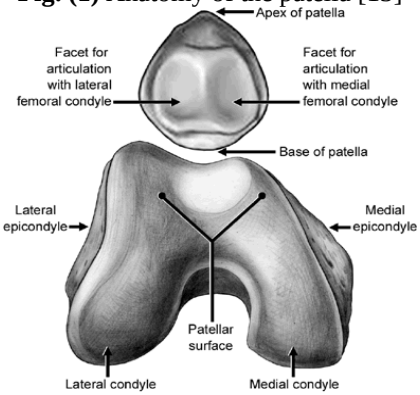

Fig. (2) Anatomy of the trochlea [14]

Acute traumatic patellar dislocation is characterised by a combination of inherent and extrinsic causes. Intrinsic factors include patella alta (high-riding patella) **(Figure 3)**, trochlear dysplasia (shallow or deformed trochlear groove) **(Figure 4)**, increased Q angle (the angle between the line of quadriceps force and the patellar tendon), and ligamentous laxity. By modifying the patellofemoral joint's typical biomechanics, these anatomical characteristics can predispose individuals to patellar instability [15].

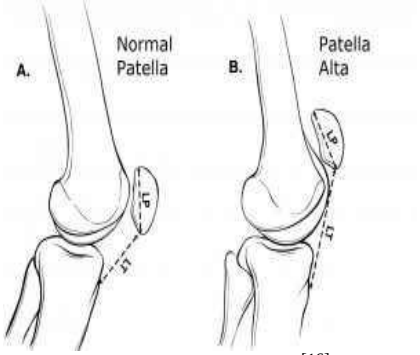

Fig. (3) Patella alta [16]

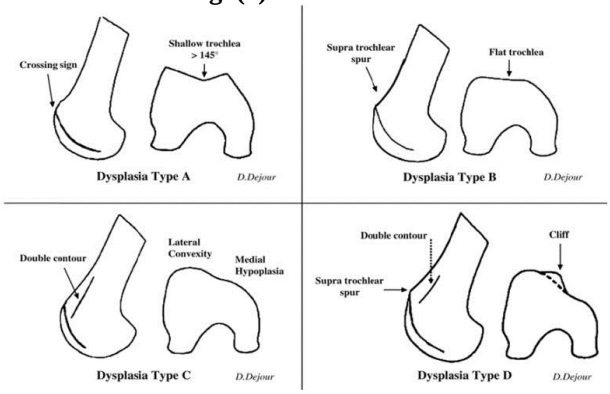

Fig. (4) Dejour classification of Trochlear Dysplasia [17]

Traumatic occurrences, such as abrupt changes in direction or deceleration movements, and involvement in sports that involve repetitive knee loading and pivoting motions are

extrinsic variables that contribute to patellar instability. These external stresses may exceed the patellofemoral joint's stabilising capabilities, resulting in patellar dislocation [10].

Acute traumatic dislocation of the patella can result in a variety of complications and injuries. These may include tears or avulsion fractures of the MPFL, damage to the articular cartilage of the patella or trochlea, injury to the medial patellotibial ligament, or other soft tissue injuries within the knee joint. These concomitant injuries can further contribute to joint instability and functional limitations [18].

While nonoperative management, including immobilization, bracing, and physical therapy, is typically employed for first-time patellar dislocations, recurrent instability and persistent functional impairments often necessitate surgical intervention. Surgical techniques aim to restore the integrity and balance of the patellofemoral joint, with MPFL reconstruction playing a prominent role due to its critical role in stabilizing the patella [19].

3. Nonoperative Management of First-Time Patellar Dislocation:

First-time patellar dislocations are normally treated nonoperatively, with the goals of relieving symptoms, promoting healing, and restoring normal knee function. Depending on the characteristics of the individual patient, the severity of the dislocation, and the presence of accompanying injuries, specific treatment approaches may differ. Herein are presented the current guidelines and recommendations for the nonoperative care of first-time patellar dislocation, as well as the reasoning for the most often employed treatment approaches [20]**(Table 1)**.

Table (1) Nonoperative management options for first-time patellar dislocation

Nonoperative Management Options	Rationale
Brief Immobilization	Allows healing of injured structures, such as the MPFL and associated soft tissues. Minimizes pain, reduces swelling, and protects the knee during the early stages of recovery. Provides external support to the patellofemoral joint.
Bracing	Maintains proper patellar alignment and limits excessive lateral movement. Improves patellar tracking during weight-bearing activities.
Physical Therapy	Restores strength, flexibility, and neuromuscular control of the knee joint. Addresses muscular imbalances or weaknesses contributing to instability. Strengthens quadriceps and other muscles around the knee for improved patellar tracking and stability. Enhances neuromuscular control and proprioception for joint stability. Facilitates functional range of motion, reduces pain and swelling, and aids in safe return to activities and sports participation.

Brief Immobilization:

Following the initial dislocation of the patella, knee immobilisation is frequently advised. Typically, this entails the use of a knee immobiliser or a hinged knee brace, which limit knee movement and offer joint stability. The purpose of immobilisation is to allow injured structures, such as the MPFL and related soft tissues, to heal and restore stability. During the early phases of rehabilitation, immobilisation also aids in decreasing discomfort, reducing swelling, and protecting the knee [21].

Bracing:

In addition to temporary immobilisation, bracing is a regular component of nonoperative therapy for patellar dislocation occurring for the first time. Knee braces created specifically for patellar stabilisation are used to offer external support to the patellofemoral joint and reduce the risk of recurring instability. Typically, these braces are intended to preserve appropriate patellar alignment, restrict excessive lateral movement, and enhance patellar tracking during weight-bearing exercises. Bracing can provide greater joint stability while permitting controlled motion and rehabilitation [22].

Physical Therapy:

Physical therapy is an essential component of the nonoperative management of patellar dislocation occurring for the first time. It seeks to restore the knee's strength, range of motion, and neuromuscular control, correcting any

muscular imbalances or deficits that may lead to instability. Typically, physical therapy interventions combine therapeutic exercises, manual therapy approaches, and functional training. Specific workouts may concentrate on strengthening the quadriceps, hamstrings, and hip muscles, as well as enhancing the knee's dynamic stability and proprioception. Physical therapists may also use treatments such as cold therapy, electrical stimulation, and ultrasound to alleviate pain and inflammation [23].

The justification for physical therapy is complex. Initially, targeted workouts strengthen the muscles surrounding the knee joint, especially the quadriceps, which play a critical role in patellar stability. These muscles can be strengthened to improve patellar tracking and lessen the likelihood of future dislocations. The second objective of physical therapy is to improve neuromuscular control and proprioception, which are crucial for maintaining joint stability and preventing bouts of instability. Patients can better handle stresses acting on the patellofemoral joint by enhancing their muscular coordination and control. Physical therapy can assist a safe return to normal activities, including sports participation, by restoring functional range of motion, reducing discomfort and swelling, and facilitating a return to normal activities [24].

The objective of nonoperative treatment for first-time patellar dislocation is to restore stability, alleviate symptoms, and avoid recurrence of instability. Some patients may require surgical intervention, particularly if there are chronic functional limits, recurring dislocations, or concurrent injuries, despite the fact that many patients react effectively to nonoperative treatment. Typically, the choice to continue with surgery depends on the patient's clinical presentation, imaging results, and response to conservative treatment [25].

4. Recurrent Patellar Instability and Functional Limitations:

Recurrent patellar instability refers to the recurrence of patellar dislocation or subluxation following the original dislocation. Despite nonoperative care techniques for first-time patellar dislocation, a substantial proportion of patients may develop recurrent instability, resulting in chronic functional limits and diminished quality of life. In this section, we will address the prevalence of repeated patellar instability after an initial dislocation, as well as the functional restrictions observed by those with recurrent instability [26].

The prevalence of recurrent patellar instability varies between research; however, a large proportion of patients are known to be affected. Up to 44 percent of persons who undergo patellar dislocation for the first time may develop recurring instability, according to research. This recurrence rate highlights the significance of identifying and treating the underlying causes of instability in order to prevent future episodes and functional impairments [27].

Individuals with recurrent patellar instability frequently experience a variety of functional impairments that have a major influence on their ability to engage in daily activities and participate in sports. These constraints include [28]:

I. Persistent Pain:

Numerous patients with recurrent patellar instability suffer from persistent pain in the patellofemoral joint. The pain might be acute or dull and may occur with activities involving knee movement, such as walking, climbing stairs, or playing sports. The persistent pain might restrict functional mobility and impair quality of life as a whole [29].

II. Mechanical Symptoms:

Recurrent instability can result in mechanical symptoms such as catching, popping, or giving way. These symptoms are caused by aberrant patellar tracking or subluxation, which interrupts joint function temporarily. Mechanical symptoms can be unpredictable and produce significant fear and worry in patients, hindering their ability to engage in daily activities and sports [30].

III. Difficulties Returning to Sports:

Returning to sports or physical activities after a recurrence of patellar instability might provide substantial obstacles for individuals. The concern of recurring dislocation and functional limitations connected with it may hinder athletes from engaging completely or competing at their pre-injury level. Lack of confidence in knee stability and fear of re-injury can have psychological and emotional consequences, affecting an individual's athletic performance and well-being [31].

IV. Functional Limitations:

Recurrent patellar instability can lead to functional restrictions that extend beyond involvement in sports. Pain and anxiety can make simple tasks such as crouching, kneeling, or sitting for extended durations difficult. Individuals may also experience difficulties with activities of daily living, including dressing, bathing, and climbing stairs. These functional limitations can significantly impact independence, mobility, and overall quality of life [32].

5. Surgical Treatment Options for Recurrent Patellar Instability:

When nonoperative management fails to address the functional limitations and recurrent episodes of patellar instability, surgical intervention becomes necessary. Various surgical approaches have been developed to address recurrent patellar instability and restore stability to the patellofemoral joint [33].

✓ **Medial Patellofemoral Ligament (MPFL) Reconstruction:**

MPFL reconstruction has gained popularity as the preferred surgical procedure for addressing recurrent patellar instability. The MPFL, being the primary restraint to lateral patellar displacement, is often the focus of surgical intervention. During MPFL reconstruction, the torn or insufficient MPFL is reconstructed using autograft or allograft tissue. Common graft choices include hamstring tendon, quadriceps tendon, or patellar tendon. The graft is routed through tunnels in the femur and patella, recreating the anatomic MPFL attachment points [34].

✓ **Tibial Tubercle Osteotomy:**

Tibial tubercle osteotomy is another surgical technique used in the management of recurrent patellar instability, particularly in cases associated with patella alta or excessive lateralization of the tibial tubercle. This procedure involves repositioning the tibial tubercle to improve patellar alignment and tracking. By shifting the insertion point of the patellar tendon, tibial tubercle osteotomy can reduce lateral forces acting on the patella, enhancing stability [35].

✓ **Trochleoplasty:**

Trochleoplasty is performed when trochlear dysplasia is present and contributing to patellar instability **(Figure 5)**. This procedure involves reshaping the trochlear groove to deepen and normalize its anatomy, promoting proper patellar tracking. Trochleoplasty can be performed using various techniques, such as the sulcus-deepening trochleoplasty or the recess trochleoplasty, depending on the severity of trochlear dysplasia and individual patient factors [36].

Fig.(5) Trochlear dysplasia is a risk factor for patellar instability [16]

✓ **Lateral Release:**

Lateral release procedures were previously used to address patellar instability; however, they are now less commonly performed due to associated risks. Lateral release involves releasing or lengthening the lateral retinaculum to alleviate lateral patellar compression. However, it can lead to overconstraint and increased medial patellar instability, and therefore, it is generally avoided or performed selectively in specific cases [37].

Controversies and Considerations in Surgical Procedure Choice:

Choosing the appropriate surgical procedure for recurrent patellar instability remains a topic of debate and requires careful consideration of several factors. These factors include [38]:

Understanding the underlying pathophysiology that contributes to patellar instability is essential for selecting the appropriate surgical technique. To establish the most optimal surgical strategy, factors such as MPFL tear pattern, trochlear dysplasia, patella alta, and anatomical anomalies need to be assessed. When selecting a surgical technique, it is essential to consider the unique qualities and requirements of each patient. Age, activity level, concomitant injuries, joint laxity, and patient goals and expectations must be examined to ensure that the selected operation is compatible with the patient's lifestyle and demands. Expertise and experience with various surgical methods play a substantial part in the decision-making process. Surgeons may have preferences based on their expertise and

outcomes, and it is crucial to select a technique that the surgeon is proficient in doing [39].

Every surgical treatment carries with it the possibility of complications and hazards. These should be discussed with the patient to ensure their consent is informed. Understanding the potential advantages and disadvantages of each method enables better informed decision making. When selecting a surgical method, it is important to evaluate the long-term effects, such as the restoration of patellar stability, the reduction of functional limits, and patient satisfaction. Reviewing the literature and information on the outcomes of various procedures might aid in making an informed decision [40].

6. Hamstring Autograft Reconstruction of MPFL using Dual Patella Docking Technique:

The choice of graft for MPFL restoration is essential for optimal results. Due to its advantageous qualities, the hamstring autograft derived from the semitendinosus and gracilis tendons has gained popularity. Among the justifications for employing hamstring autograft are [41]:

A. Adequate strength and biomechanical properties: The hamstring tendons provide the required strength and tensile qualities for repair of the MPFL. The semitendinosus and gracilis tendons are appropriate for grafting because to their length and durability [42].

B. Anatomical similarity: The hamstring tendons share the same diameter and thickness as the natural MPFL, making anatomical restoration possible. This helps replicate the MPFL's natural biomechanics and function [43].

C. Minimal donor site morbidity: It has been demonstrated that harvesting the hamstring autograft has little donor site morbidity and minimal effect on hamstring strength and function. This makes it a safe and dependable solution for grafting [43].

Dual Patella Docking Technique:

Dual patella docking is a surgical procedure for reconstructing the MPFL using hamstring autograft. It entails constructing bone tunnels in the femoral and patellar bones to anchor the graft, so permitting anatomical repair of the MPFL. The twin patella docking technique has a number of benefits and possible advantages [44]:

I. Anatomic graft placement: The approach permits precise insertion of the graft in the femoral and patellar bone tunnels, simulating the MPFL's natural attachment locations. This assists in restoring patellar tracking and stability [45]. **II. Enhanced graft fixation:** The dual patella docking approach enables superior transplant fixation by employing both the femoral and patellar bone tunnels. This increases the MPFL's stability and decreases the likelihood of graft failure or slippage [46]. **II. Preservation of patellar anatomy:** The approach minimises the risk of patellar problems and cartilage injury by preserving the patellar articular surface and avoiding extensive resection or drilling [47]. **II. Restoration of normal kinematics:** Dual patella docking attempts to restore the patellofemoral joint's natural biomechanics, allowing for optimal range of motion, stability, and function [48].

Surgical Steps:

The following are possible surgical processes involved in hamstring autograft reconstruction of MPFL using the twin patella docking technique [49]:

1. Graft Harvesting: The semitendinosus and gracilis tendons are collected by a tiny incision at the insertion of the pes anserinus. The tendons are dissected, sized suitably, and prepared for graft implantation [50]. **2. Femoral Tunnel Creation:** At the anatomic attachment location of the MPFL, often along the medial femoral condyle, a femoral bone tunnel is produced. This can be accomplished utilising a combination of tunnel preparation and drilling procedures [51]. **3. Patellar Tunnel Creation:** A patellar bone tunnel is constructed in the medial patellar facet while preserving the MPFL's native patellar attachment point. Avoiding excessive resection or injury to the patellar cartilage is a priority [51]. **4. Graft Fixation:** Through the femoral and patellar tunnels, the hamstring autograft is passed. Fixation devices, such as interference screws, can be utilised to secure the graft. Dual patella docking involves simultaneous fixation of the graft at the femoral and patellar ends [51]. **5. Closure and Rehabilitation:** The incisions are closed and wound care is administered. To assist healing, restore range of motion, and strengthen the surrounding muscles, postoperative rehabilitation, including a structured physical therapy programme, is commenced [51].

7. Comparing with other techniques:

When comparing the dual patella docking procedure to other surgical approaches for MPFL repair, it is essential to assess the reported outcomes, problems, and benefits of each approach [52].

Dual Patella Docking Technique: As previously described, the twin patella docking approach entails constructing femoral and patellar bone tunnels to attach the hamstring autograft. This procedure is intended to reestablish MPFL attachment points and offer

optimal graft fixation. Principal benefits and reported results of the twin patella docking method include: **Anatomical graft placement:** The procedure permits precise graft placement, which replicates the natural attachment locations of the MPFL and restores normal patellar tracking and stability. **Enhanced graft fixation:** Utilizing both the femoral and patellar bone tunnels provides robust graft fixation, hence decreasing the chance of graft failure or slippage. **Preservation of patellar anatomy:** The procedure protects the patellar articular surface, hence reducing the likelihood of patellar problems and cartilage degradation. **Restoration of normal kinematics:** By recreating the MPFL anatomically, the dual patella docking approach seeks to restore the patellofemoral joint's natural biomechanics, allowing for optimal range of motion and stability [53].

Alternative Surgical Techniques:

There are a variety of surgical options for MPFL reconstruction, each with its own considerations and reported outcomes [54].

- Transtibial technique involves creating a tibial tunnel and passing the graft through the tibial and femoral tunnels. It is a simpler approach but may result in non-anatomical graft placement.
- Medial patellar tunnel technique uses a single patellar tunnel for graft fixation. It provides good patellar fixation but may have challenges in achieving accurate femoral tunnel placement.
- Medial quadriceps tendon technique utilizes the medial portion of the quadriceps tendon for graft reconstruction. It provides good graft strength but may require extensive dissection and have potential donor site complications.

Comparing the dual patella docking technique with these alternative approaches, several factors should be considered:

Studies have shown favorable outcomes with the dual patella docking technique, including improved patellar stability, reduced recurrent instability, and high patient satisfaction rates. However, comparative studies specifically comparing outcomes between different techniques are limited and further research is needed. Complications can occur with any surgical technique. Potential complications associated with MPFL reconstruction include graft failure, patellar fracture, patellar tendon injury, and recurrent instability. The incidence and severity of complications may vary among techniques, and individual patient factors can also influence outcomes. The dual patella docking technique offers advantages such as anatomical graft placement, enhanced fixation, and preservation of patellar anatomy. These advantages contribute to improved patellar stability and restoration of normal joint kinematics [55].

8. Considerations for Anatomical Reconstruction:

In the surgical treatment of recurrent patellar instability, achieving anatomical repair of the medial patellofemoral ligament (MPFL) is of utmost importance. The purpose of anatomical reconstruction is to restore the native ligament's structure, function, and biomechanics, which can have substantial effects on patellofemoral stresses and kinematics [56].

A. Patellofemoral Loads and Kinematics:

The MPFL is essential for preserving patellar stability and preventing lateral patellar movement. By reconstructing the MPFL anatomically, the patellofemoral joint can reestablish its natural equilibrium, permitting proper patellar tracking and lowering the risk of patellar instability. Anatomical reconstruction helps to distribute patellofemoral stresses more uniformly, hence limiting excessive stress on the patella and decreasing the chance of future issues such as patellar maltracking or arthritis [57].

B. Respect for Patellar and Femoral Insertion Anatomy:

During MPFL reconstruction, the dual patella docking technique highlights the significance of honouring both the patellar and femoral insertion anatomy. The patellar insertion of the MPFL is normally positioned along the medial edge of the patella, whereas the femoral insertion lies along the adductor tubercle or medial epicondyle of the femur. By duplicating the natural insertion locations and orientation of the MPFL, the repaired ligament can more closely imitate the function of the original ligament and offer stability throughout the knee's range of motion [44].

Respecting the anatomy of the patellar and femoral insertions provides numerous advantages. Initially, it aids in maintaining the appropriate tension of the repaired ligament, hence enabling adequate resistance to lateral patellar movement. Second, it permits a more precise restoration of patellofemoral joint mechanics, such as patellar tracking and contact pressures. Finally, it enhances long-term stability and minimises the risk of problems associated with non-anatomical reconstruction, including aberrant patellar forces, patellofemoral discomfort, and graft failure [10].

9. Future Directions:

Several areas of MPFL reconstruction require additional investigation and development. Exploring alternate graft choices, such as quadriceps tendon or allografts, and analysing augmentation procedures can provide useful insights into the efficacy of graft selection and augmentation. Additionally, considering patient-specific factors and tailoring the surgical approach accordingly, including age, sex, anatomical variations, and activity level, can help develop personalized treatment algorithms. Long-term follow-up studies are necessary to assess the durability and sustainability of MPFL reconstruction outcomes, including functional outcomes, recurrence rates, and the development of patellofemoral osteoarthritis [58].

10. Conclusion and future prospective:

MPFL reconstruction using hamstring autograft by the dual patella docking technique holds promise in the surgical treatment of recurrent patellar instability. The use of hamstring autograft offers adequate strength and anatomical similarity to the native MPFL, while minimizing donor site morbidity. The dual patella docking technique provides advantages in terms of graft fixation and tensioning, contributing to improved outcomes. However, further research is needed to explore alternative graft options, refine surgical techniques, establish standardized rehabilitation protocols, and evaluate long-term outcomes. Addressing these areas of future directions and controversies will enhance the understanding and management of recurrent patellar instability.

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