

General

A Landscape of Recent Literature on the Predictors of Success and Failure in Medial Patellofemoral Ligament Reconstruction

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Medial patellofemoral ligament reconstruction is a widely used surgical technique to address patellar instability. This procedure is influenced by several key factors, including patient-specific factors, anatomical considerations, graft selection, tunnel placement, tensioning, fixation methods, postoperative rehabilitation, and potential complications. Various graft options, including autografts and allografts, have been studied, with research indicating no significant differences in pain reduction, return to activity, or failure rates between the two. However, some studies suggest allografts may have a lower failure rate and recurrence of patellar instability compared to autografts. The precise placement of the femoral tunnel is essential for successful reconstruction. Ensuring that the graft is neither too tight nor too loose during fixation contributes significantly to the biomechanical stability of the knee. Different fixation methods, including suture anchors and interference screws, have been compared, with both providing reliable initial fixation strength. Postoperative rehabilitation is another crucial aspect, with studies showing that accelerated protocols can yield favorable outcomes without increasing the risk of recurrent instability. Complications such as recurrent dislocations, patellar fractures, and infections have been reported, with technical errors during surgery being a major contributing factor. A comprehensive approach, involving precise surgical technique and tailored rehabilitation protocols, is necessary to minimize complications and optimize long-term success.

1. INTRODUCTION

Patellofemoral instability is a common condition that can cause a variety of symptoms and, in some cases, progress to patellar dislocation. The incidence of patellar dislocation is approximately 5.8 per 100,000 individuals.¹ Several risk factors for patellofemoral instability have been identified, emphasizing its multifactorial nature. Among these factors are trochlear dysplasia, patella alta, and an increased tibial tuberosity-trochlear groove distance.² The management of patellofemoral instability remains a subject of ongoing debate, with treatment options ranging from conservative approaches to various surgical interventions. Surgical strategies encompass both soft tissue repair techniques and bone reconstruction procedures. A number of studies have shown that surgical treatment tends to produce more favorable outcomes than conservative methods, particularly in cases of recurrent instability.^{3,4} The risk of redislocation with conservative treatment for patellofemoral instability can be as high as 66%.⁵ Medial patellofemoral ligament (MPFL) reconstruction is considered one of the most effective treatment options for patellofemoral instability, whether used as an isolated procedure or in combination with other surgical techniques.⁶⁻⁹ The success of MPFL reconstruction is highly dependent on precise patient se-

lection and the accurate determination of surgical indications.⁴ The aim of this review is to identify the factors that predict both the success and failure of MPFL reconstruction in the treatment of patellofemoral instability. By analyzing patient-specific variables, surgical techniques, and postoperative outcomes, the study seeks to provide a deeper understanding of what influences the effectiveness of MPFL reconstruction. This information can help refine patient selection, optimize surgical planning, and improve overall management strategies for achieving better clinical outcomes.

2. METHODS

The review began with an initial search of titles and abstracts using PubMed, Google Scholar, and Scopus databases. Search terms included variations of “medial patellofemoral ligament reconstruction,” “predictors of success and Failure,” and “clinical outcomes.” Relevant studies published in English and in peer-reviewed journals, were then selected and full-text articles were reviewed.

3. PATIENT-RELATED PREDICTORS

3.1. AGE

The influence of age and skeletal maturity on the outcomes of patellofemoral instability treatment has been widely investigated yet remains a subject of debate. Some authors have explored the influence of a closed versus open growth plate on outcomes, irrespective of the patient's age, while others have focused on the age at the time of the first dislocation, or the timing of surgery, as key predictors. Arendt et al. and Sanders et al. identified a higher risk of re-dislocation in patients with skeletal immaturity.^{10,11} Zhang et al. found that patients under 18 years old at the time of their first patellar dislocation face a higher risk of re-dislocation.¹² However, there is some inconsistency in the literature, with various studies recommending different ages for intervention, ranging from ≤ 16 years to 25 years.⁵ A study by Hiemistra et al. examined the impact of age at the time of surgery. The findings revealed that a 10-year increase in age at the time of surgery was associated with lower Banff Patellofemoral Instability Instrument (BPFI) scores, reflecting a decline in both quality of life and clinical outcomes.¹³ Supporting this, research by Zlak et al. also indicated that older age negatively affected surgical outcomes.¹⁴ On the other hand, studies have shown that younger patients, especially adolescents, tend to achieve more favorable results following MPFL reconstruction. Specifically, research published by Örs et al. demonstrated that MPFL reconstruction significantly enhanced sports participation and activity levels in adolescents with recurrent patellar dislocation.¹⁵

3.2. BODY MASS INDEX

The impact of Body Mass Index (BMI) on the outcomes of MPFL reconstruction in recent studies has yielded mixed findings. A Study by Sharma et al. concluded that isolated MPFL reconstruction is a safe and effective intervention for managing patellar instability, with optimal functional outcomes observed in individuals with a BMI of approximately 20 to 21.¹⁶ Sherman et al. conducted a retrospective review to evaluate the outcomes, activity levels, and complication rates associated with MPFL reconstruction in both obese and non-obese patients. Their findings indicated that MPFL reconstruction remains a safe and effective surgical intervention for obese individuals, demonstrating low complication rates and notable improvements in the majority of patient-reported outcomes. However, when compared to individuals with a BMI below 30, obese patients exhibited lower quality-of-life and activity scores at the final follow-up assessment.¹⁷ However, a recent study conducted by Zhan et al. in 2024 reported that patients with an elevated BMI had a higher incidence of surgical failure. Despite this, both groups exhibited significant improvements in functional outcomes following surgery.¹⁸

3.3. SEX

Zheng et al. demonstrated that males, in contrast to females, are more prone to experiencing a complete MPFL

rupture following a lateral patellar dislocation.¹² Astur et al. conducted a comparative study evaluating the outcomes of two surgical techniques for MPFL reconstruction. Their findings indicated that there were no significant differences in surgical outcomes when stratified by sex.¹⁹ In contrast, Walsch et al. found that male patients were more likely to report higher satisfaction with the surgery.²⁰

3.4. HYPERMOBILITY

Hypermobility is considered a potential risk factor for patellofemoral instability. In a case-control study by Howells et al., the influence of hypermobility on surgical outcomes was assessed. The results revealed that patients with hypermobility showed significant functional improvement following surgery, as well as a willingness to undergo the procedure again. However, their functional gains were considerably lower compared to the control group. Hypermobility should not be considered a contraindication for MPFL reconstruction.²¹

3.5. PSYCHOSOCIAL FACTORS

Psychosocial factors play a crucial role in determining the outcomes of MPFL reconstruction surgeries. Research by Hurley et al. demonstrated that patients who failed to return to sports after MPFL reconstruction exhibited poor psychological preparedness, with fear of re-injury being the predominant reason.²² Depression, in particular, has been linked to poorer postoperative outcomes, including increased pain levels and reduced functional recovery.²³

4. ANATOMICAL PREDICTORS

4.1. PATELLA ALTA

Patella alta refers to an abnormal elevation of the patella in relation to the femur, trochlear groove, or tibia. This anatomical variation is widely acknowledged as a key contributor to patellofemoral instability.²⁴ To assess and define patella alta, several measurement techniques have been established, with the Insall-Salvati Index and the Caton-Deschamps Index being among the most commonly utilized (Figure 1). However, despite its clinical relevance, there remains a lack of consensus regarding standardized cutoff values, appropriate treatment indications, and optimal corrective approaches.²⁵ The impact of patella alta on the outcomes of isolated MPFL reconstruction remains a topic of ongoing debate in the literature. A systematic review conducted by Bartsch et al. indicated that both individuals with patella alta and those with normal patellar height experienced satisfactory post-surgical results. Moreover, the study suggested that tibial tubercle distalization may not be essential in cases of mild patella alta.²⁶ Similarly, research by Luceri et al. supported this conclusion, demonstrating that MPFL reconstruction contributes to the correction of patellar height in patients with mild patella alta, thereby questioning the necessity of additional bony procedures.²⁷ A systematic review by Pappa et al. concluded that patella alta did not negatively impact post-surgical out-

comes in the majority of the studies analyzed.²⁴ Conversely, findings by Sappey et al. identified patella alta as potential risk factors for failure following isolated MPFL reconstruction, suggesting an increased likelihood of recurrent instability in such cases.²⁸

4.2. TROCHLEAR DYSPLASIA

Trochlear dysplasia categorized into four types (A-D) according to Dejour's classification system (Figure 2).² High-grade dysplasia, including types B through D, as well as a sulcus angle greater than 145°, are generally regarded as unfavorable conditions for isolated MPFL reconstruction and may necessitate additional surgical considerations.²⁹ Liu et al. suggested that isolated MPFL reconstruction can be a successful treatment option even in the presence of trochlear dysplasia, provided there is no substantial elevation in the Tibial Tuberosity-Trochlear Groove distance.³⁰ The study by Hiemstra et al. revealed significant postoperative improvements; however, patients with high-grade trochlear dysplasia had lower disease-specific quality of life scores compared to those with low-grade or no dysplasia.³¹ Hopper et al. found that patients with severe trochlear dysplasia experienced a higher rate of recurrent dislocations following isolated MPFL reconstruction.³² Furthermore, a meta-analysis by Zaffagnini et al. comparing MPFL reconstruction outcomes with and without trochleoplasty in patients with trochlear dysplasia found that isolated MPFL reconstruction proved effective for those with moderate dysplasia, but adding trochleoplasty significantly lowered the rates of redislocation in patients with severe dysplasia.³³

4.3. TTTG DISTANCE

The Tibial Tuberosity-Trochlear Groove (TTTG) distance is a key parameter for evaluating patellar alignment and assessing patellofemoral instability (Figure 3). A TTTG distance exceeding 20 mm is regarded as abnormal and may suggest a higher likelihood of patellar instability or dislocation.² Matsushita et al. suggested that an increased TTTG distance does not necessarily compromise the success of MPFL reconstruction.⁶ Similarly, a study by Erickson et al. supports the effectiveness of isolated MPFL reconstruction in managing patellar instability, regardless of TTTG distance.⁷ Guevel et al. suggested in his meta-analysis that TTO may not offer additional benefits when combined with MPFL reconstruction in patients with increased TTTG distance, potentially reducing the need for additional surgical procedures and their associated risks.⁸ Conversely, studies indicate that a TTTG distance exceeding 20 mm is associated with increased lateral patellar instability, in which case the combined approach of tibial tubercle osteotomy (TTO) and MPFL reconstruction may provide superior outcomes by addressing both soft tissue and bony alignment abnormalities.³⁴

4.4. CORONAL LOWER LIMB ALIGNMENT

The Q angle, determined by lines extending from the anterior superior iliac spine through the patella to the tibial tubercle, is a clinical marker of the coronal alignment, and an increased Q angle, commonly seen in conditions like genu valgum (knock-knee deformity), has been linked to several patellofemoral disorders.³⁵ Valgus malalignment significantly increases the load on the reconstructed MPFL, with biomechanical studies showing that even a 5° deformity elevates these forces, and a 10° deformity further intensifies stress across various knee flexion angles, emphasizing the need to correct valgus alignment for better surgical outcomes.³⁶ Evaluating and adjusting coronal lower limb alignment, particularly the Q-angle and valgus malalignment, is essential for managing patellofemoral instability, with corrections through surgical intervention or growth modulation significantly improving the success of MPFL reconstruction.³⁷

5. SURGICAL TECHNIQUE PREDICTORS

5.1. GRAFT TYPE

Various graft options, including autografts and allografts, are available for MPFL reconstruction. Kumar et al. found no significant differences between hamstring autografts and hamstring allografts regarding return to activity, changes in pain scores, or failure rates.⁹ Similarly, Hestenberg et al. indicated no statistically significant differences between autografts and allografts in terms of failure rates, patient-reported outcomes, pain levels, or complications.³⁸ Conversely, a systematic review by Colasanti examined 12 studies involving 336 knees that underwent MPFL reconstruction with allografts. The findings demonstrated a lower recurrence rate of lateral patellar instability in the allograft group compared to the autograft group.³⁹ These findings align with those of Aliberti et al., who compared clinical outcomes and the risk of recurrent patellar dislocation between autograft and allograft MPFL reconstructions. While both groups exhibited significant improvements in clinical outcomes, graft failure occurred more frequently in the autograft group, indicating that allografts may be the preferred option due to their lower failure rates.⁴⁰ A systematic review and meta-analysis conducted by McNeilan et al. assessed multiple autograft options, including gracilis, semitendinosus, quadriceps, patellar tendon, and adductor tendon grafts. The findings indicated consistently low rates of recurrent instability across all autograft types in adult patients. The study concluded that the choice of autograft does not significantly affect the success of isolated MPFL reconstruction, suggesting that graft selection can be guided by the surgeon's preference and expertise.⁴¹ Sasaki et al. investigated recently the clinical outcomes of using Fiber Tape combined with knotless anchors. Their findings suggest that this technique provides favorable stability and functional improvement, demonstrating its potential as a viable alternative to traditional graft options.⁴²

5.2. GRAFT PLACEMENT AND TENSIONING

The Schottle point refers to a precise anatomical location on the femur that serves as the origin of the MPFL. It is a critical landmark for reconstructive surgery of the MPFL.⁴³ Precise identification of this anatomical point is critical for achieving biomechanically effective MPFL reconstruction, as improper placement or positioning of the femoral tunnel is a major determinant of failure.⁴⁴ A systematic review by Walsh emphasized the importance of placing the femoral tunnel at the Schottle point, which was found to be pivotal for favorable results.⁴⁵ Additionally, a study by Hiemstra et al. investigated the precision of femoral tunnel placement in 206 MPFL reconstructions, reporting that 92.3% of the tunnels were positioned at an acceptable or ideal location relative to the Schottle point. However, they found no significant relationship between the accuracy of tunnel placement and disease-specific quality-of-life outcomes, suggesting that factors beyond tunnel placement may also play a role in influencing patient recovery and satisfaction.⁴⁶ It is also crucial to recognize the misconception of overtightening the MPFL, as this structure naturally becomes physiologically tense in response to lateralizing forces applied to the patella.⁴⁷ Optimal results are achieved when the fixation is performed under minimal tension, regardless of the graft type or fixation angle.⁴⁵ Furthermore, the study by Walsh suggested that the femoral tunnel's diameter should exceed that of the graft by at least 2 mm, thereby minimizing the risk of graft advancement and preventing overtensioning.⁴⁵

5.3. FIXATION METHOD

Research by Walsh et al. demonstrated that both suture anchors and transosseous tunnels offered comparable ultimate load to failure, stiffness, and elongation properties.⁴⁵ In a separate investigation, Smith et al. evaluated the effectiveness of all-suture anchor fixation in comparison to larger interference screws in MPFL reconstruction. Their findings indicated that all-suture anchor fixation yielded similar cyclic elongation values to those observed with interference screw fixation, supporting its potential as a viable fixation technique. All-suture anchors offer the advantage of requiring less bone removal during MPFL reconstruction, which may reduce the risk of patellar fractures.⁴⁸

6. POSTOPERATIVE AND REHABILITATION PREDICTORS

Magnussen et al. investigated the effects of two distinct rehabilitation protocols on patient-reported outcomes and recurrent patellar dislocation, comparing a restrictive approach with early post-operative bracing and weightbearing limitations to an accelerated plan allowing immediate weightbearing and excluding bracing, and found that the accelerated protocol did not increase the risk of recurrent patellar dislocation or negatively impact patient-reported outcomes after isolated MPFL reconstruction.⁴⁹ The de-

cision to resume sports activities should be based on a comprehensive evaluation that includes both objective and subjective assessments, rather than being solely reliant on postoperative timeframes.⁵⁰ In a meta-analysis by Platt et al., the average time to return to sport was found to be 6.7 months postoperatively.⁵¹

7. COMPLICATIONS

Despite effectiveness of MPFL reconstruction, various studies have highlighted a range of potential complications associated with the procedure. A systematic review analyzing data from 1,478 patients reported complication rates ranging from 0% to 32.3%, with recurrent instability occurring in up to 10.7% of cases. Additionally, the same review identified patellar fractures in as many as 8.3% of knees.⁵² Research suggests that many of these complications are linked to technical errors during surgery.⁵³ Improper placement of bone tunnels or fixation devices, along with the use of a graft that is too short or poorly tensioned, can compromise the patellar bone's strength and create abnormal forces on the patella, increasing the risk of fractures.⁵⁴ The transosseous suture approach for hamstring graft fixation reduces the risk of patellar fractures by eliminating the need for bone tunnels and hardware, thereby minimizing stress concentrations that could contribute to fractures.⁵⁵ Ensuring appropriate patient selection, precise tunnel placement, and evaluating the necessity of concurrent realignment procedures are crucial steps in reducing the likelihood of adverse outcomes.⁵³

8. DISCUSSION

This review highlights the multifactorial nature of outcomes following MPFL reconstruction, emphasizing key patient-related, anatomical, surgical, and rehabilitation considerations. This emphasizes the need for individualized patient selection, meticulous surgical execution, and structured rehabilitation protocols. Skeletal maturity, BMI, and psychosocial factors should be integrated into preoperative evaluations to optimize outcomes. Preoperative imaging is essential for assessing anatomical risk factors and determining the necessity of adjunctive procedures. Intraoperatively, precise graft placement and tensioning are imperative to prevent complications. Furthermore, rehabilitation protocols that prioritize early mobilization appear beneficial in enhancing recovery without compromising stability. Despite advancements in MPFL reconstruction, knowledge gaps remain regarding long-term outcomes and standardized treatment algorithms. The heterogeneity of patient populations and surgical techniques across studies complicates the establishment of universal guidelines. Future research should aim to refine patient selection criteria, particularly concerning age and BMI thresholds, and explore the long-term efficacy of different graft choices and adjunctive procedures. Large-scale, multicenter studies with standardized surgical and rehabilitation protocols are necessary to provide clearer recommendations. Additionally, further investigation into the psychological determinants of recov-

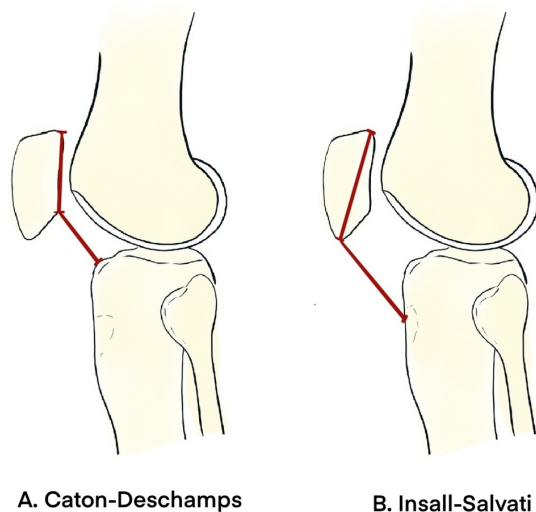


Figure 1. Illustration of two common measurement techniques used for patellar height assessment.

A: The Caton-Deschamps Index: Measured as the ratio of the distance from the lower pole of the patella to the tibial plateau divided by the length of the patellar articular surface. B: The Insall-Salvati Index: Measured as the ratio of the length of the patellar tendon to the greatest diagonal length of the patella

ery and return to sport may enhance patient satisfaction and overall functional outcomes.

In conclusion, MPFL reconstruction is an effective intervention for patellofemoral instability, but success depends on a comprehensive approach integrating patient-specific, anatomical, and technical factors. Ongoing advancements in surgical techniques and rehabilitation strategies continue to refine clinical practice, though further research is required to optimize long-term results and establish standardized management guidelines.

CONFLICT OF INTEREST

The author declares no conflicts of interest.

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ETHICAL APPROVAL AND CONSENT

This manuscript does not include any research involving human participants or animals conducted by the author.

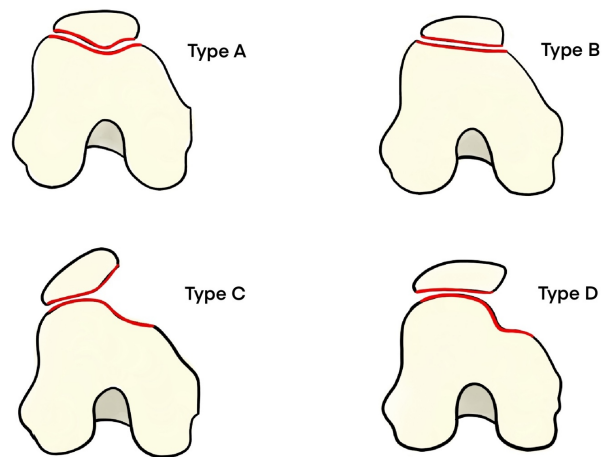


Figure 2. Dejour classification of trochlear dysplasia, illustrating the four types.

Type A: Mild dysplasia with a shallow trochlear groove. Type B: Flattened or convex trochlea. Type C: Asymmetrical trochlea with a convex lateral facet and a hypoplastic medial facet. Type D: Severe dysplasia characterized by a cliff pattern with a double contour sign.

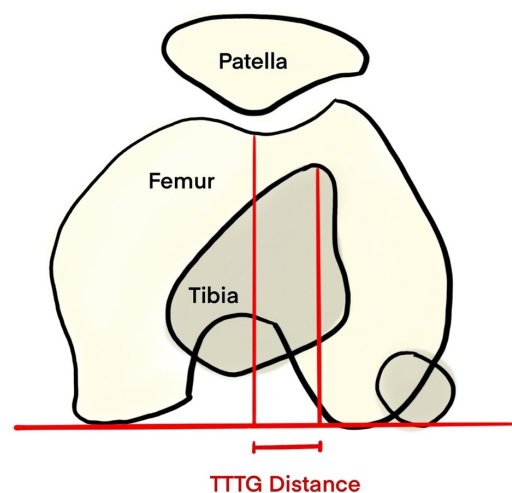


Figure 3. Measurement of the tibial tuberosity trochlear groove distance on axial imaging.

The distance is determined as the horizontal distance between the deepest point of the trochlear groove and the most anterior point of the tibial tuberosity.

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