



# Medial Patellofemoral Ligament Reconstruction Using a Quadriceps Tendon Autograft in a Patient with Open Physes

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**Abstract:** Recurrent patellar dislocations are correlated with an elevated risk for further patellar dislocations. Chronic patellar instability is a disabling issue for some patients and may require surgical intervention for proper treatment. Risk factors for recurrent dislocations include medial patellofemoral ligament (MPFL) tears, patella alta, trochlear dysplasia, and increased tibial tubercle to trochlear groove distance. Surgical management must be based on a patient's unique joint pathoanatomy and typically requires medial patellofemoral ligament reconstruction, with or without accompanying procedures such as tibial tubercle osteotomy or sulcus-deepening trochleoplasty. Chronic patellar instability in minors with open growth plates, requires alternative MPFL reconstruction techniques to prevent physeal injury, because of the close proximity of the femoral physis to the MPFL insertion. This article discusses the authors' preferred technique for surgical treatment of recurrent patellar instability with a medial patellofemoral ligament reconstruction using a quadriceps tendon autograft.

Chronic patellar dislocations can be debilitating, especially among younger patients.<sup>1</sup> Although secondary patellar dislocations occur relatively infrequently, they have been correlated with a significant risk for recurrent dislocations, which have been reported in up to 50% of patients in some studies.<sup>1</sup> As a result, surgical management is often recommended for individuals with recurrent dislocations, because nonoperative treatment is

more likely to be ineffective in this setting. Chronic patellar instability in minors with open growth plates, however, requires alternative MPFL reconstruction techniques to prevent any physeal injury because of the close proximity of the adjacent physis of the medial patellofemoral ligament (MPFL) (graft) insertion. This article will discuss the risk factors for chronic patellar instability, indications for surgical intervention, and our technique to treat recurrent patellar instability with MPFL reconstruction with a quadriceps tendon autograft in a minor with open physes (Table 1).

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## Objective Diagnosis

Trochlear joint morphology is classified by the Dejour classification using lateral radiographs (Fig 1).<sup>2</sup> Lateral radiographs are also used to calculate the Caton-Deschamps index for patellar height, which these authors prefer to the Insall-Salvati ratio because of its accuracy in knee flexion (Fig 1).<sup>3</sup> The trochlear groove depth and sulcus angle, on the other hand, are determined by axial, or sunrise, radiographs. A sulcus angle of 145° or greater indicates dysplastic trochlea (Fig 2).<sup>2</sup> Lateral trochlear inclination in the setting of MPFL injury is also assessed with magnetic resonance imaging, because axial radiographs tend to underestimate lateral inclination (Fig 3). Computed tomography is the preferred diagnostic tool to accurately measure the

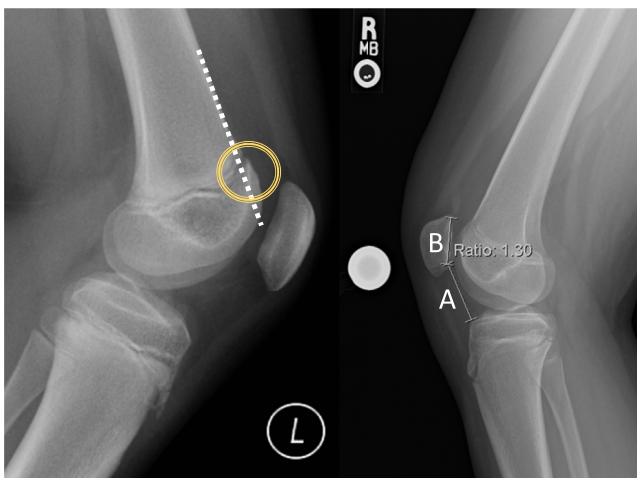
**Table 1.** Pearls and Pitfalls**Pearls**

- Use a partial-thickness quad tendon graft to preserve postoperative quad function.
- Re-insert arthroscope after fixation to observe appropriate patellar tracking in trochlear groove.
- When using quad tendon autograft, low profile sutures anchors can be used instead of tunnels with tenodesis screws.
- Use of adductor tubercle as landmark for MPFL origin on femur eliminates need to find Schottle's point with fluoroscopy.
- Make a wide retinacular channel for easy graft passage.

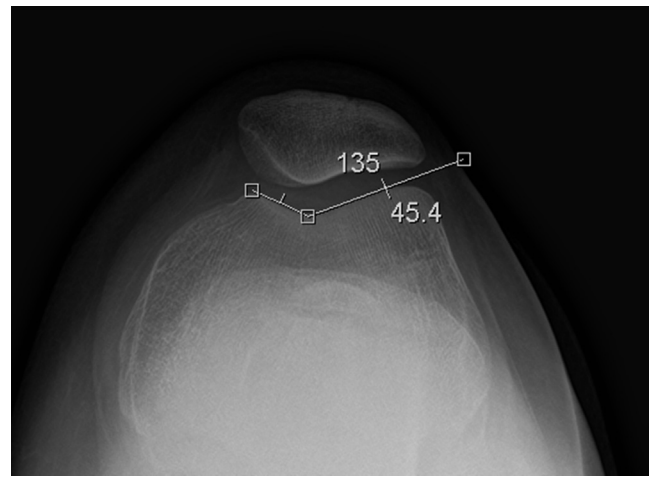
**Pitfalls**

- Open physis = Danger! Use intraoperative fluoroscopy to ensure suture anchors do not violate the physis.
- Quad tendon in smaller individuals may be of insufficient length to reconstruct MPFL.
- Take care not to overconstrain the MPFL graft, thus increasing risk of medial patellar arthritis.
- To prevent the quad tendon autograft from rolling, elevate the graft a few millimeters off the proximal patella and place a suture anchor in the proximal patella to secure the graft.
- Take care not to inadvertently sew the channel closed when securing the quad tendon autograft to the proximal patella.

MPFL, medial patellofemoral ligament.



**Fig 1.** The Caton-Deschamps Index (CDI) and Dejour classification system are used to measure patellar height and trochlear dysplasia, respectively. These are demonstrated on a (R) knee lateral radiograph and a (L) knee lateral radiograph above from a skeletally immature patient with open physes. On the (R) knee, CDI is measured as a ratio of the distance between the anterior angle of the tibia and the inferior articular surface of the patella (A) to the length of the articular surface of the patella (B). The Dejour system classifies trochlear dysplasia; the (L) knee radiograph above demonstrates Dejour type B trochlear dysplasia, with a supratrochlear spur (femoral condyle extends beyond the anterior femoral cortex, dashed white line) and a crossing sign (trochlear groove line passes lateral condylar line, circled in (L) radiograph). A CDI > 1.3 indicates patella alta. Dejour type B trochlear dysplasia is typically treated with medial patellofemoral ligament reconstruction and sulcus-deepening trochleoplasty. In a patient with open physes, as above, trochleoplasty cannot be performed because of the risk of damaging the physis.

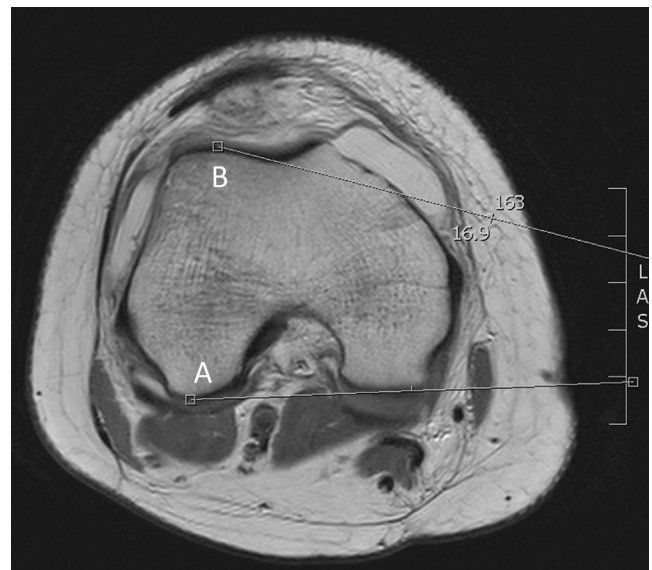


**Fig 2.** Trochlear sulcus angle measured on a right knee sunrise or axial radiograph. One measurement of trochlear dysplasia is the measurement of the angle between the medial and lateral facets of the trochlear groove, the innermost part of which is the intercondylar sulcus. The average sulcus angle is  $138^\circ \pm 5^\circ$ ; a sulcus angle  $>145^\circ$  is diagnostic for trochlear dysplasia or an abnormally flat trochlear groove. The above image demonstrates a right knee with a normal sulcus angle.

tibial tubercle to trochlear groove distance and evaluate the need for tibial tubercle osteotomy (TTO).<sup>4</sup>

### Indications for Surgery

Secondary and chronic patellar dislocations should be treated surgically, given their high recurrence rates and persistent symptoms.<sup>5</sup> In patients with Dejour type A



**Fig 3.** Lateral trochlear inclination is the angle between the posterior condylar line (A) and the lateral facet of the femoral trochlear (B). Below  $11^\circ$ , this parameter is correlated with trochlear dysplasia and patellar instability. Lateral trochlear inclination is usually performed on magnetic resonance imaging (MRI), as demonstrated on the right knee MRI above (lateral trochlear inclination of 16.9).

**Table 2.** Advantages and Disadvantages

## Advantages

- Quadriceps tendon is already anchored on the patella, making for a strong construct
- Use of suture anchors with Quad tendon to minimize tunnel drilling
- MPFL reconstruction can be performed in skeletally immature patients, whereas TTO and trochleoplasty are contraindicated

## Disadvantages

- Risk of distal femoral growth arrest or angular deformity because of drilling or suture anchor placement
- Does not address underlying patella alta, elevated TT-TG distance, or trochlear dysplasia

MPFL, medial patellofemoral ligament; TT-TG, tibial tubercle to trochlear groove; TTO, tibial tubercle osteotomy.

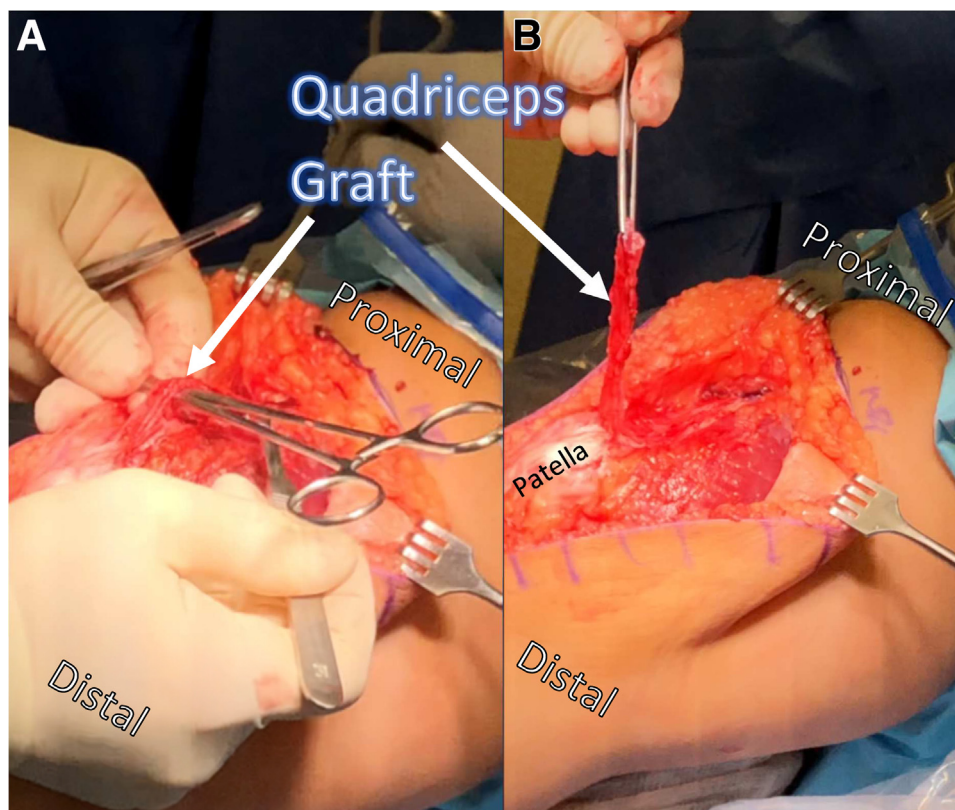
trochlear dysplasia, an MPFL reconstruction alone is indicated. Patients with Dejour type B, C, or D dysplasia may require a sulcus-deepening trochleoplasty in addition to MPFL reconstruction, because the MPFL provides static restraint against lateral subluxation of the patella in extension. Colvin et al.<sup>5</sup> have demonstrated that the MPFL contributes up to 60% of the lateral displacement resistance of the patella.<sup>6</sup> Trochleoplasty and TTO, however, are contraindicated in patients with an open physis or diffuse patellofemoral arthritis (Kellgren and Lawrence grade IV) because of increased risk of pain intolerance or premature closure of the growth plate (Table 2).<sup>7</sup>

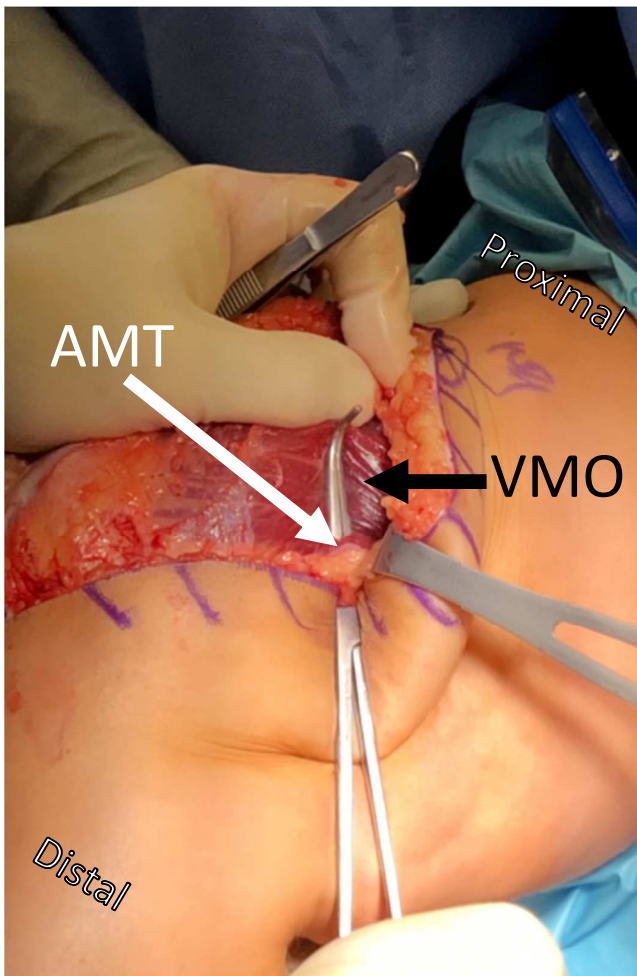
A CT-derived tibial tubercle to trochlear groove distance greater than 20 mm indicates an increased risk of patellar dislocation, normally indicating a medializing TTO.<sup>2</sup> A Canton-Deschamps index greater than 1.4 is diagnostic of patella alta, and a distalization procedure of the tubercle is also required in adult patients (Fig 1). In a patient with open physes, however, the portion of the tibial physis traversing the tubercle should not be violated and likewise with sulcus-deepening trochleoplasty and the distal femoral physis. MPFL reconstruction is the best option for these patients, with less risk to the distal femoral physis from the use of suture anchors for graft fixation. This article will describe an approach for a right knee MPFL reconstruction with a quadriceps tendon autograft in a minor with an open physes.

### Patient Positioning and Anesthesia

The patient is placed in the supine position and induced with general anesthesia. A high-thigh tourniquet is placed on the operative leg, and a comparative bilateral examination is performed with the patient under anesthesia, with assessment of heel height, range of motion, presence of a “J-sign,” patellar subluxation from full extension through flexion, Lachman’s test, posterior drawer, varus stress, and valgus stress tests. Prophylaxis against infection is given, and the extremity is prepped and draped in a sterile manner.

**Fig 4.** Graft harvest: Chronic patellar instability in adults may be treated with some combination of medial patellofemoral ligament (MPFL) reconstruction, sulcus-deepening trochleoplasty, and tibial tubercle osteotomy (TTO). In minors with open physes, trochleoplasty and TTO would violate the femoral and tibial physis; therefore MPFL reconstruction alone is performed. A partial-thickness quadriceps tendon graft is harvested, measuring 8 cm long by 8 to 10 mm wide to reconstruct the MPFL. (A) The medial and lateral sides of a right knee quadriceps tendon graft have been outlined with a scalpel, and an instrument placed beneath the graft holds tension for its proximal end to be detached. (B) The graft is held with forceps, demonstrating its distal attachment to the superior patellar pole is left intact. White arrows indicate the graft.





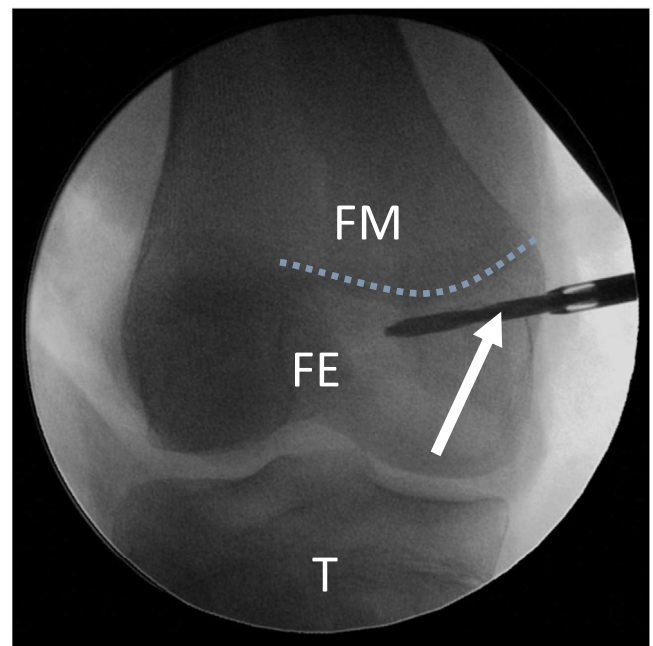
**Fig 5.** Adductor magnus tendon: Medial patellofemoral ligament (MPFL) reconstruction may be accomplished with a partial-thickness quadriceps tendon graft, passed through a retinacular channel and secured 1.9 mm anterior and 3.8 mm distal to the adductor tubercle (AT). To most efficiently find the AT, the surgeon may locate the vastus medialis oblique (VMO) through a medial parapatellar incision. At the distal edge of the VMO, the adductor magnus tendon (AMT) can be located and followed distally to the adductor tubercle. In this image, an instrument is placed beneath the AMT in a right knee.

### Surgical Technique

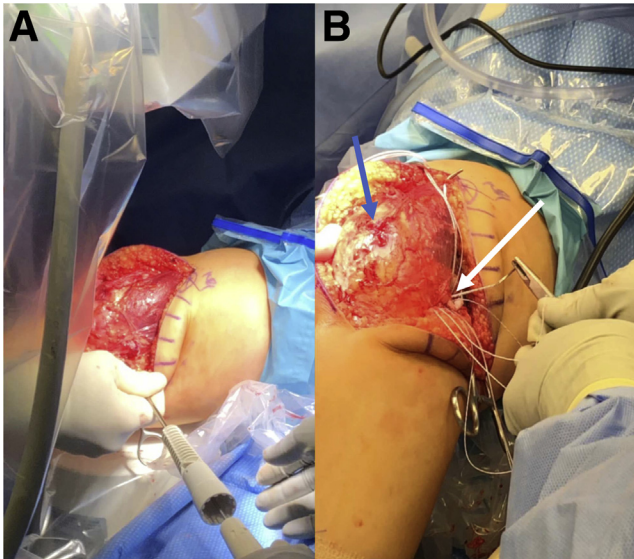
The surgical technique is presented in [Video 1](#). An anterior midline incision is first performed, originating 6 cm proximal to the patella and extending down to the tibial tubercle, to expose the extensor mechanism. A spinal needle is placed to identify the superior pole of the patella. A partial-thickness quadriceps tendon graft is then harvested, measuring 8 cm long and 8 to 10 mm wide, and is left intact on the superior pole of the patella ([Table 1](#), [Fig 4](#)). The graft is brought back upon itself and sutured to the patellar soft tissues and periosteum with a Q-Fix anchor (Smith & Nephew) to prevent it from rolling onto itself. A channel is then created along the native course of the MPFL to pass the MPFL graft.

The adductor magnus tendon is then identified, which acts as a landmark for the adductor tubercle and medial epicondyle ([Fig 5](#)). The MPFL femoral attachment is found approximately 1.9 mm anterior and 3.8 mm distal to the adductor tubercle.<sup>8</sup> Fluoroscopic imaging is then used to identify the patient's open physis and prevent growth plate violation with drilling and placement of the suture anchors ([Fig 6](#)). The growth plate is located close to the adductor tubercle, and care is taken to prevent fixation anchors from crossing the physis. Two Q-Fix suture anchors are then placed at the anatomic MPFL attachment site on the femur ([Fig 7](#)). Anteroposterior radiographs are subsequently obtained of the right knee documenting sparing of the patient's physis with the suture anchors.

Attention is then turned toward arthroscopy. Medial and lateral portals are first incised. The camera is then inserted, and the joint is insufflated with normal saline solution. Any loose bodies present within the knee are subsequently removed. Chondroplasty is performed for any observed areas of chondromalacia, flaps, or other cartilage pathology. The arthroscopy is then ended, and all fluid is expressed from the knee joint.



**Fig 6.** Intraoperative fluoroscopy: Patients with chronic patellar dislocations who have open physes may be treated with medial patellofemoral ligament (MPFL) reconstruction, without trochleoplasty or tibial tubercle osteotomy to preserve the physis. However, even in this procedure, the suture anchors used to secure the graft (in this case, partial-thickness quadriceps tendon, right knee) run the risk of violating the physis when they are drilled. Thus intraoperative fluoroscopy (as above) is imperative to verify that the drill bit avoids the physal line when deploying suture anchors. White arrow = drill bit; dotted line = physical line. FM, femoral metaphysis; FE, femoral epiphysis; T, tibia.



**Fig 7.** Suture anchor fixation of medial patellofemoral ligament (MPFL) graft: MPFL reconstruction for chronic patellar dislocations may be accomplished with a quadriceps tendon graft. In this right knee with open physes, placement of suture anchors under intraoperative fluoroscopy can be seen (A). After placing the suture anchors, the partial-thickness quadriceps tendon graft is passed through a channel cleared under the medial retinacular tissue and secured to a location 1.9 mm anterior and 3.8 mm distal to the adductor tubercle. (B) The blue arrow indicates where the quadriceps tendon graft, still attached at the superior pole of the patella and folded on itself and secured with a suture anchor, is passed into the lateral aspect of the medial retinaculum. The white arrow indicates where the graft emerges from the medial aspect of the medial retinaculum over the adductor tubercle; here, it is secured with 2 additional suture anchors.

The knee is positioned to 45° of knee flexion. Next, the MPFL graft is passed down the previously created channel and tied down to its femoral attachment using sutures from the Q-Fix anchors. After the first anchor is tied down, the patella should be viewed arthroscopically to ensure that the patient's patella fits anatomically within the trochlear groove and is not subluxed. All remaining fixation sutures are then tied down in the trochlear groove (Fig 8). Appropriate tensioning of the patella is verified with each succeeding suture. With the knee in full extension, the patella should translate approximately one quadrant laterally with minimally applied pressure (Fig 9). With knee flexion past 90°, the MPFL graft should be loose with no significant tension noted. Once confirmed, the remaining sutures can then be secured.

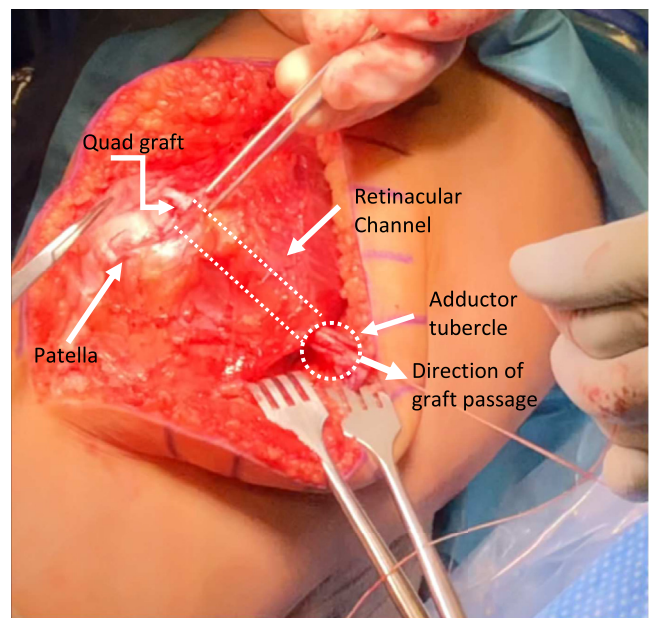
The tourniquet is let down, and the deep tissues are closed with 0 and 2-0 Vicryl. The skin is closed, instead, with Monocryl (Johnson & Johnson) and Steri-Strips. A sterile dressing is loosely draped on top. The knee is placed in an immobilizer in full extension.

## Postoperative Rehabilitation

The patient will be nonweightbearing for 6 weeks and will begin supervised rehabilitation therapy on postoperative day 1. Flexion is limited to 90° during the first 2 weeks of rehabilitation and then increased as tolerated with passive range of motion. Rehabilitation exercises should center on quadriceps activation, straight-leg raises, and ankle pumps with the knee immobilized and should be performed 3 to 5 times each day. Return to normal activity tends to occur 6 to 9 months after surgery.<sup>2</sup>

## Discussion

Reconstruction of the MPFL is a viable, standalone option for minors with recurrent patellar instability. In a study by Vavken et al.,<sup>9</sup> MPFL reconstruction was shown as the most effective treatment option in pediatric and adolescent patients with normal or restored knee anatomy. MPFL reconstruction with a quadriceps tendon autograft has also been reported to be well tolerated. One outcome study reporting on 25 MPFL reconstructions with quadriceps tendon demonstrated a



**Fig 8.** Medial patellofemoral ligament (MPFL) reconstruction is indicated in patients with recurrent patellar dislocations and a dysplastic trochlea, or for traumatic injuries of the MPFL leading to recurrent dislocations of the patella. In the above intraoperative photo of a right knee, the patella and origin of the quadriceps tendon graft ("Quad graft") are indicated. The advantage of the split-thickness quadriceps graft is that it is comprised of autologous tissue, retains a biological fixation point on the superior pole of the patella, and has a less deleterious effect on quadriceps tendon function after surgery than a full-thickness graft. The graft will then be passed beneath the medial retinaculum in the direction indicated, and fixed with suture anchors at the adductor tubercle (within circle, obscured by the medial end of graft above).



**Fig 9.** Intraoperative testing of patellar translation is performed after medial patellofemoral ligament reconstruction (MPFLR). This is procedure is indicated in patients with trochlear dysplasia or traumatic injury to the MPFL causing recurrent patellar dislocations. Patellar horizontal movement is measured in quadrants of motion, indicated in the above intraoperative photo of a right knee after MPFLR with solid white lines. After fixation of the graft, the surgeon assesses patellar stability with horizontal motion (dashed lines) to detect any persistent subluxation.

100% patient satisfaction rate at an average follow-up of 2 years.<sup>10</sup>

The partial-thickness quadriceps tendon graft technique is also advantageous because the patellar attachment of the quadriceps graft is left intact. This, along with the use of suture anchors rather than bone tunnels, ameliorates some of the potential risk of patellar fractures, a complication reported in as many as 26% of patients.<sup>11</sup> Additionally, the MPFL and quadriceps tendon share an embryological origin from ventral mesenchyme and are thus very similar in terms of anatomy.<sup>10</sup> It is also economically and cosmetically beneficial because no patellar implants are necessary, and one less skin incision is necessary given that the quadriceps tendon is obtained through the same longitudinal required for MPFL reconstruction. Recent systematic reviews and meta-analyses have reported that surgically addressing patellar dislocations in pediatric patients with MPFL reconstruction leads to a recurrence of dislocations in <5% of patients at 5 years<sup>12</sup> or a recurrence of patellofemoral instability of 2%.<sup>13</sup> Therefore surgical management with MPFL reconstruction of chronic patellofemoral instability in

skeletally immature patients using a partial-thickness quadriceps tendon graft, as in the above technique, is an efficacious procedure recommended by these authors.

## References

1. Fithian DC, Paxton EW, Stone ML, et al. Epidemiology and natural history of acute patellar dislocation. *Am J Sports Med* 2004;32:1114-1121.
2. Dejour H, Walch G, Nove-Josserand L, et al. Factors of patellar instability: An anatomic radiographic study. *Knee Surg Sports Traumatol Arthrosc* 1994;2:19-26.
3. Caton J, Deschamps G, Chambat P, et al. Patella infera. Apropos of 128 cases. *Rev Chir Orthop Reparatrice Appar Mot* 1982;68:317-325 [in French].
4. Ho CP, James EW, Surowiec RK, Gatlin CC, Ellman MB, Cram TR, Dornan GJ, LaPrade RF. Systematic technique-dependent differences in CT versus MRI measurement of the tibial tubercle-trochlear groove distance. *Am J Sports Med* 2015;43:675-682.
5. Colvin AC, West RV. Patellar instability. *J Bone Joint Surg Am* 2008;90:2751-2762.
6. Dejour D, Saggin P. The sulcus deepening trochleoplasty: The Lyon's procedure. *Int Orthop* 2010;34:311-316.
7. LaPrade RF, Cram TR, James EW, Rasmussen MT. Trochlear dysplasia and the role of trochleoplasty. *Clin Sports Med* 2014;33:531-545.
8. LaPrade RF, Engebretsen AH, Ly TV, et al. The anatomy of the medial part of the knee. *J Bone Joint Surg Am* 2007;89:2000-2010.
9. Vavken P, Wimmer MD, Camathias C, Quidde J, Valderrabano V, Pagenstert G. Treating patella instability in skeletally immature patients. *Arthroscopy* 2013;29:1410-1422.
10. Nelitz M, Dreyhaupt J, Williams SRM. Anatomic reconstruction of the medial patellofemoral ligament in children and adolescents using a pedicled quadriceps tendon graft shows favorable results at a minimum of 2-year follow-up. *Knee Surg Sports Traumatol Arthrosc* 2018;26:1210-1215.
11. Shah JN, Howard JS, Flanigan DC, Brophy RH, Carey JL, Lattermann C. A systematic review of complications and failures associated with medial patellofemoral ligament reconstruction for recurrent patellar dislocation. *Am J Sports Med* 2012;40:1916-1923.
12. Shamrock AG, Day MA, Duchman KR, Glass N, Westermann RW. Medial patellofemoral ligament reconstruction in skeletally immature patients: a systematic review and meta-analysis. *Orthop J Sports Med* 2019;7(7):1-7.
13. Wilkens OE, Hannink G, van de Groes SAW. Recurrent patellofemoral instability rates after MPFL reconstruction techniques are in the range of instability rates after other soft tissue realignment techniques. *Knee Surg Sports Traumatol Arthrosc* 2020 Jun;28:1919-1931.