Technical Note

Medial Patellofemoral Reconstruction Using Quadriceps Tendon Autograft, Tibial Tubercle Osteotomy, and Sulcus-Deepening Trochleoplasty for Patellar Instability

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Abstract: Recurrent patellar dislocations have been correlated with an elevated risk of further patellar dislocations, often requiring surgical treatment. Risk factors include medial patellofemoral ligament (MPFL) tears, patella alta, trochlear dysplasia, and an increased tibial tubercle–trochlear groove distance. Surgical management must be based on a patient's unique joint pathoanatomy and may require MPFL reconstruction with tibial tubercle osteotomy or trochleoplasty either alone or in combination. This article discusses our preferred technique for surgical treatment of recurrent patellar instability with MPFL reconstruction using a quadriceps tendon autograft, an open trochleoplasty, and a tibial tubercle osteotomy for patients with patella alta, trochlear dysplasia, and an increased tibial tubercle–trochlear groove distance.

Chronic patellar dislocations can be a debilitating issue for some patients. Although secondary patellar dislocations occur infrequently, they have been correlated with a significant risk of recurrent dislocations, as high as 50% in some studies.[1] Owing to this risk, surgical management is recommended because nonoperative management may result in persistent symptoms. This article discusses the risk factors for chronic patellar instability, surgical indications, and our technique to treat recurrent patellar instability with medial patellofemoral ligament (MPFL) reconstruction, an open trochleoplasty in patients with severe trochlear dysplasia (Fig 1), and a tibial tubercle osteotomy (TTO) in patients with patella alta or an increased tibial tubercle–trochlear groove (TT-TG) distance (Fig 2).

Objective Diagnosis

Lateral radiographs are used to classify the trochlear morphology according to Dejour type (Fig 1)[2] and to calculate the Caton-Deschamps ratio to assess patella alta.[3] The trochlear groove sulcus angle is determined by axial radiographs at 30° of knee flexion, with an angle of 145° or greater indicating a dysplastic trochlea (Fig 3).[2] Magnetic resonance imaging is used to measure lateral trochlear inclination and confirm the MPFL injury. It has been reported that lateral radiographs tend to underestimate lateral inclination[2] (Fig 4). Computed tomography is preferred to measure the TT-TG distance and is a reliable diagnostic tool used to evaluate the need for TTO.[4]

Indications for Surgery

Secondary and chronic patellar dislocations are treated surgically given their high recurrence rates and persistent symptoms.[5] MPFL reconstruction alone

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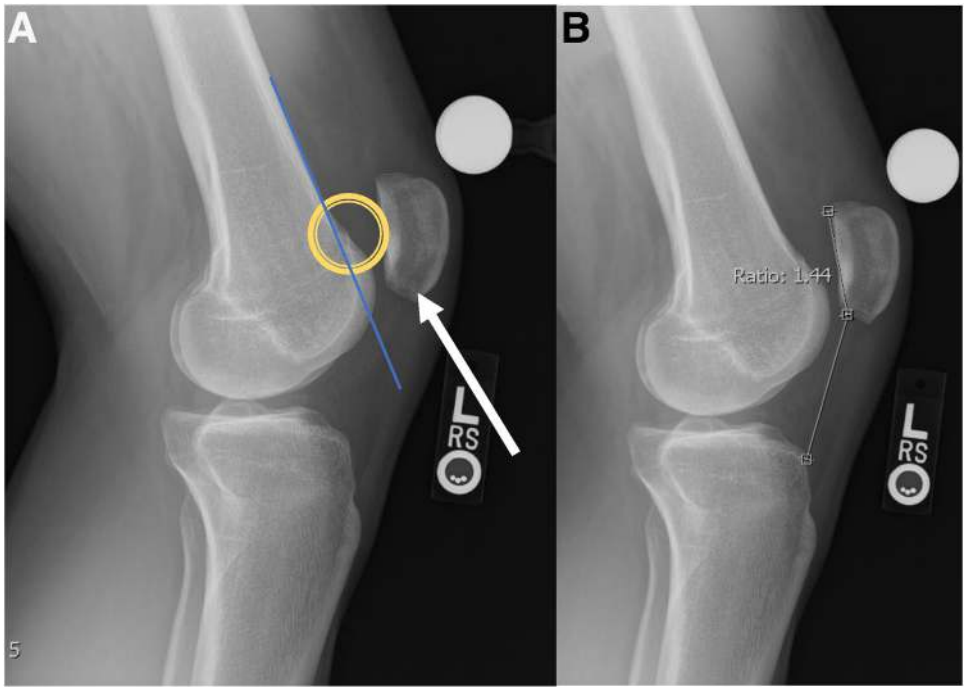

Fig 1. Dejour classification criteria of trochlear dysplasia include crossing sign, double contour lines, and supracondylar spurring. (A) Lateral radiograph showing supracondylar spur (circle, with spur protruding above blue line) and crossing sign (floor of sulcus meets condylar line, above blue line within circle). A supracondylar spur and crossing sign indicate Dejour type B trochlear dysplasia. Patients with Dejour type B, C, or D dysplasia should be evaluated for medial patellofemoral ligament reconstruction and sulcus-deepening trochleoplasty. (B) Patella alta can be measured with the Canton-Deschamps index (i.e., the ratio of the length of the articular surface of the patella to the distance from the anterior angle of the tibia to the inferior point of the patellar articular cartilage), as shown on a lateral left knee radiograph. A Canton-Deschamps index greater than 1.4 is diagnostic of patella alta. L, left knee.

is indicated in patients with Dejour type A trochlear dysplasia. Patients with Dejour type B, C, or D dysplasia should undergo MPFL reconstruction with sulcus-deepening trochleoplasty because the MPFL can contribute up to 60% of resistance to lateral displacement of the patella.[5-8] Trochleoplasty is contraindicated in patients with open physes or diffuse patellofemoral arthritis (Kellgren-Lawrence grade IV)[9] (Table 1).

A Canton-Deschamps index greater than 1.4 is diagnostic of patella alta (Fig 1), and a distalization procedure of the tubercle may be considered.[2] The computed tomography scan–derived TT-TG distance is used to assess the need for medialization. Any patient with a TT-TG distance greater than 20 mm is at higher risk of patellar dislocation, and medializing TTO should be considered.[2]

Surgical procedures to address patellofemoral reconstruction are individualized given each patient's unique joint morphology; these include MPFL reconstruction, TTO, and trochleoplasty, performed either as standalone interventions or in combination. This article will describe our approach to management of a patient with multifactorial patellar instability with MPFL reconstruction using quadriceps tendon autograft, TTO, and trochleoplasty.

Surgical Technique

Patient Positioning and Anesthesia

The patient is placed supine on the operating table and undergoes induction of general anesthesia. A high-thigh tourniquet is placed. A bilateral examination under anesthesia is conducted, including assessment of heel height, range of motion (ROM), the presence of the J-sign, and patellar subluxation from full extension through flexion, as well as the Lachman, posterior drawer, and varus and valgus stress tests.

The surgical technique is presented in Video 1. An anterior midline incision is performed, originating 6 cm proximal to the patella and extending down to the tibial tubercle, exposing the quadriceps mechanism. A partial-thickness quadriceps tendon graft, measuring 8 cm long and 8 to 10 mm wide, is marked out and then harvested and left distally intact on the superior pole of the patella (Tables 1 and 2). The graft is brought back onto itself and sutured to the patellar soft tissues and periosteum with a Q-Fix suture anchor (Smith & Nephew, London, England), preventing the graft from rolling on itself (Fig 5).

Next, the adductor magnus tendon is used as a landmark to identify the adductor tubercle and medial epicondyle. The MPFL femoral attachment is typically found

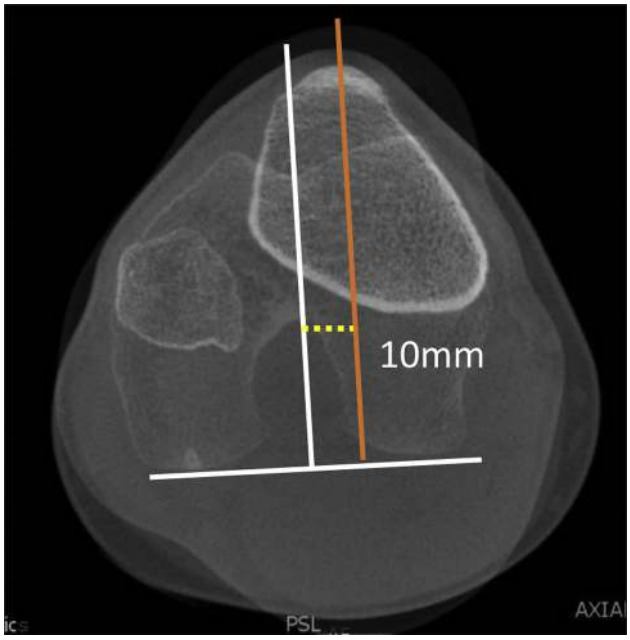

Fig 2. Tibial tubercle-trochlear groove (TT-TG) distance in a left knee, measured on axial computed tomography (CT), with the level of the tibial tubercle overlaid with an image of the level of trochlear groove. An increased TT-TG distance, defined as a distance greater than 20 mm, is associated with a greater risk of patellar dislocation. This measurement is reflective of the degree of lateralization of the tibial tubercle relative to the deepest part of the trochlea. The TT-TG distance is typically measured with axial computed tomography (CT) preferentially over magnetic resonance imaging because CT has been shown to be more accurate. An axial CT image of the left knee shows a TT-TG distance of 10 mm.

just 1.9 mm anterior and 3.8 mm distal to the adductor tubercle.[10] Two Q-Fix suture anchors are then placed at the anatomic MPFL attachment site on the femur, and a channel is cleared to pass the MPFL graft later (Fig 5).

The focus now shifts to the tibial tubercle. First, the tibial tubercle is cleared by removing the periosteum from the medial and lateral aspects of the tubercle in a proximal-distal fashion. A 2-mm drill is used to drill holes (2-3 mm apart) for 3 cm along the medial and lateral aspects of the tubercle, which are connected with a small osteotome. The tibial tubercle is then cut to a length of 3 cm using an anterior cruciate ligament saw. Distally, 12 mm of bone is excised to advance the tibial tubercle and reduce the patellar height, and a rasp and rongeur are used to prepare the area (Fig 6).

A medial parapatellar arthrotomy is incised to obtain access for the trochleoplasty with the knee at 90° of flexion. The trochlear groove is outlined in methylene blue at its distal medial and lateral margins. The periosteum is elevated around the entire trochlear margins. A small burr is used to perform a trochleoplasty with abundant irrigation, creating a V shape distal to the articular margin. The arthroscope is inserted under the bone flap to visualize this process and ensure adequate clearance (Fig 7). When the flap is thin enough to mold the margins into a V shape, 4 guide pins are inserted and 4 Bio-Compression screws (Arthrex, Naples, FL) are placed to secure the trochleoplasty.

While the tibial tubercle is held distally with a sharp towel clamp, 2 guide pins are placed to hold the distalized reduction. Cannulated screws (4.5 mm; Synthes, Warsaw, IN) and washers are then measured and placed under fluoroscopic guidance. Lateral radiographs verify correct positioning of the TTO, with screws and washers in place (Fig 8). The knee is positioned at 40° to 50° for arthrotomy closure; the patella should be more stable after trochleoplasty and TTO but lack the MPFL's restraining force in extension and early flexion.[11]

The MPFL graft is then passed down the previously created channel. The knee is flexed to 45°. The patella is held in the location where arthroscopy showed that it was centered in the trochlear groove, and the MPFL graft is secured to the femur using 2 Q-Fix anchors (Fig 9). With the knee in full extension, the surgeon should be able to translate the patella approximately 1 quadrant laterally with minimally applied pressure (Fig 10). With knee flexion past 90°, the MPFL graft should be loose. Once patellar translation through the range of motion has been confirmed, the remaining sutures are secured.

Fig 3. Trochlear dysplasia. The sulcus angle (i.e., the angle between the medial and lateral femoral facets of the trochlear groove) is a measure of trochlear dysplasia performed on axial or sunrise radiographs. A dysplastic trochlea has a flatter groove that inadequately acts as a static restraint to patellar dislocation. The average sulcus angle in normal knees is 128°. Sulcus angles of 145° or greater indicate trochlear dysplasia (shallow or flat trochlea) and increase the risk of patellar dislocation. A sunrise radiograph of the left knee shows a relatively flat sulcus angle of 143°; in a patient with recurrent dislocations, this finding raises suspicion for trochlear dysplasia.

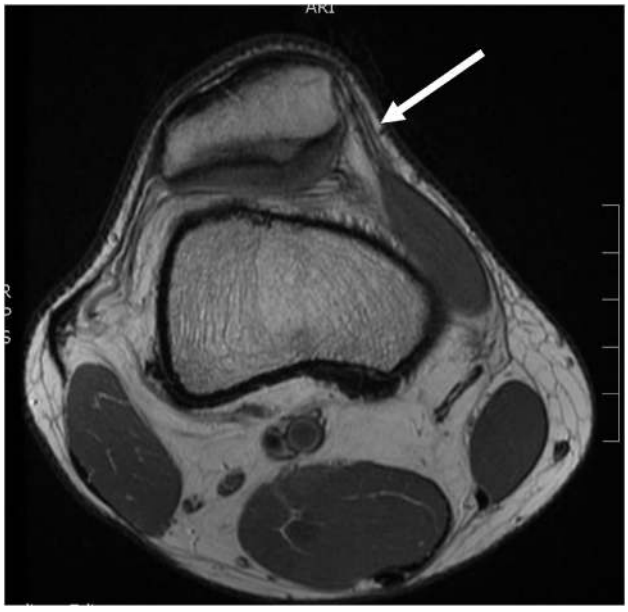

Fig 4. The medial patellofemoral ligament (MPFL) accounts for 85% to 90% of resistance to lateral subluxation of the patella in extension and, with the other retinacular structures of the anterior knee, forms a static stabilizer to patellar maltracking. On axial proton density magnetic resonance imaging, an attenuated MPFL (arrow) can be observed. Injury to the MPFL predisposes the patella to lateral subluxation, particularly during flexion when forces on the patella increase. Trochlear dysplasia decreases the bony static restraints on the patella, while MPFL injury severely impairs soft-tissue restraint.

The tourniquet is let down, the deep tissues are closed with No. 0 and No. 2-0 Vicryl (Johnson & Johnson, New Brunswick, NJ), and the skin is closed with Monocryl (Johnson & Johnson), Steri-Strips (3M, St Paul, MN), and a loosely applied sterile dressing. The knee is then placed in an immobilizer in full extension.

Table 1. Pearls and Pitfalls

Pearls	Pitfalls
The quadriceps tendon autograft should be partial thickness.	The cartilage flap should not be too thick because this creates difficulty in securing down the newly contoured trochlea.
An arthroscope should be used to scrutinize the underside of the trochleoplasty flap.	Removed bone should be saved to build up the lateral column if too much has been removed with the burr.
Tibial tubercle osteotomy should be performed before trochleoplasty to allow better visualization during trochleoplasty.	The quadriceps tendon in smaller individuals may be of insufficient length to reconstruct the MPFL.
When quadriceps tendon is used, Q-Fix anchors can be used instead of tunnels.	A suture-held reduction of the trochlear flap can be difficult during fixation; holding manual reduction minimizes cut-through or under-reduction.

MPFL, medial patellofemoral ligament.

Table 2. Advantages and Disadvantages

Advantages	Disadvantages
The quadriceps tendon is already anchored on the patella, making for a strong construct.	Sulcus-deepening trochleoplasty is technically more difficult than alternatives such as lateral facet–elevating trochleoplasty.
Use of Q-Fix anchors to secure the quadriceps tendon to the femur minimizes tunnel drilling and minimizes the need to find the Schöttle point on fluoroscopy.	Risks include trochlear flap necrosis and loss of cartilage fixation.
Sulcus-deepening trochleoplasty addresses a shallow sulcus and centralizes the patellar tracking area.	Trochleoplasty is not suitable for patients who already have advanced osteoarthritis.
Trochleoplasty can also address patellar tilt—and even height to some extent.	Patellar instability often presents at a young age, but trochleoplasty is contraindicated in patients with open physes.

Postoperative Rehabilitation

The patient is non–weight bearing for 6 weeks and starts supervised physical therapy on day 1 postoperatively. Flexion ROM is limited to 90° during the first 2 weeks of rehabilitation and then increased as tolerated with passive ROM as the knee moves into extension. Exercises should focus on repetitive knee ROM, quadriceps activation, and strengthening exercises with progressive demand per bony healing and symptoms. General strengthening for the other large muscle groups of the lower extremity is performed 3 to 4 times each day in the early rehabilitation phase. Return to normal activity occurs at 6 to 9 months postoperatively.[2]

Discussion

Studies examining trochlear dysplasia treated with trochleoplasty, both with and without MPFL reconstruction, have reported patient satisfaction rates ranging from 67% to 95.7%.[12,13] Carstensen et al.[14] performed 2-year follow-up of combined trochleoplasty and MPFL reconstruction, with or without TTO and lateral release or lengthening. They reported on 44 knees and found improvements in the International Knee Documentation Committee and Kujala scores, a 100% rate of return to work, and an 84.5% rate of return to sport. High success rates for MPFL reconstruction with TTO have been attested in the

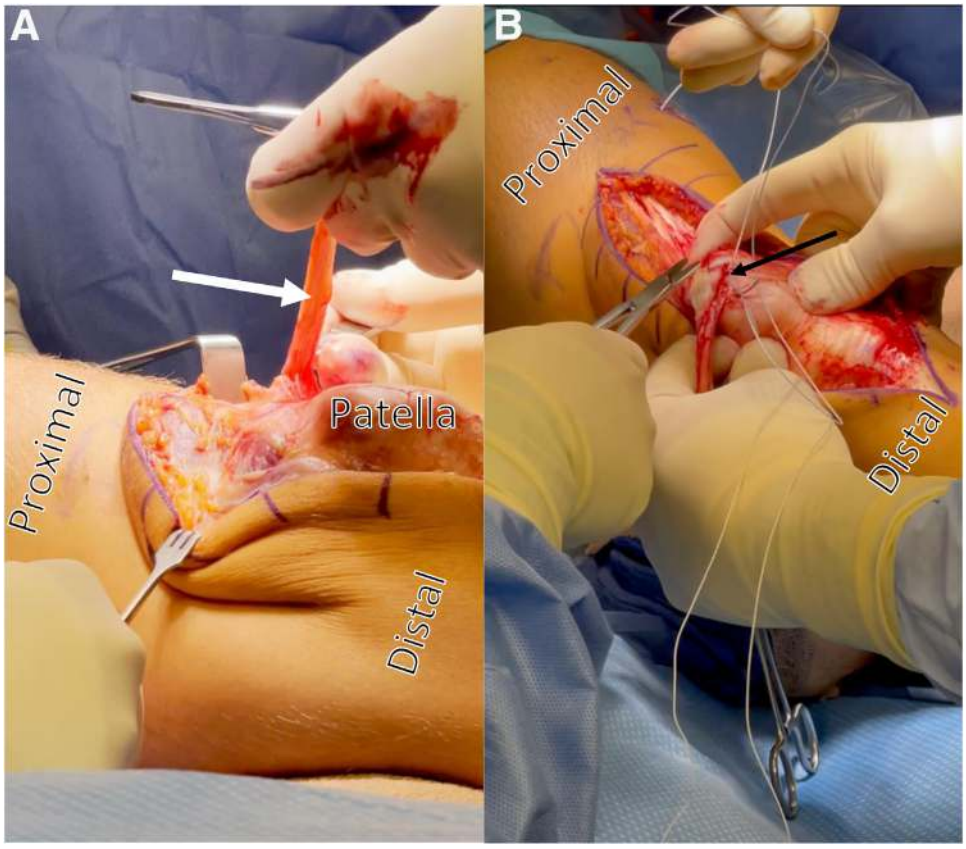

Fig 5. Partial-thickness quadriceps tendon graft. Medial patellofemoral ligament reconstruction is performed in patients with trochlear dysplasia and recurrent patellar dislocations. A partial-thickness quadriceps tendon graft is advantageous because it allows the retention of an anatomic fixation to the superior pole of the patella. (A) An 8-cm-long by 8- to 10-mm-wide graft (arrow) is harvested. (B) A suture anchor is placed in the superior medial aspect (arrow) of the patella. A free needle is used to secure the graft to the soft tissues surrounding the patella.

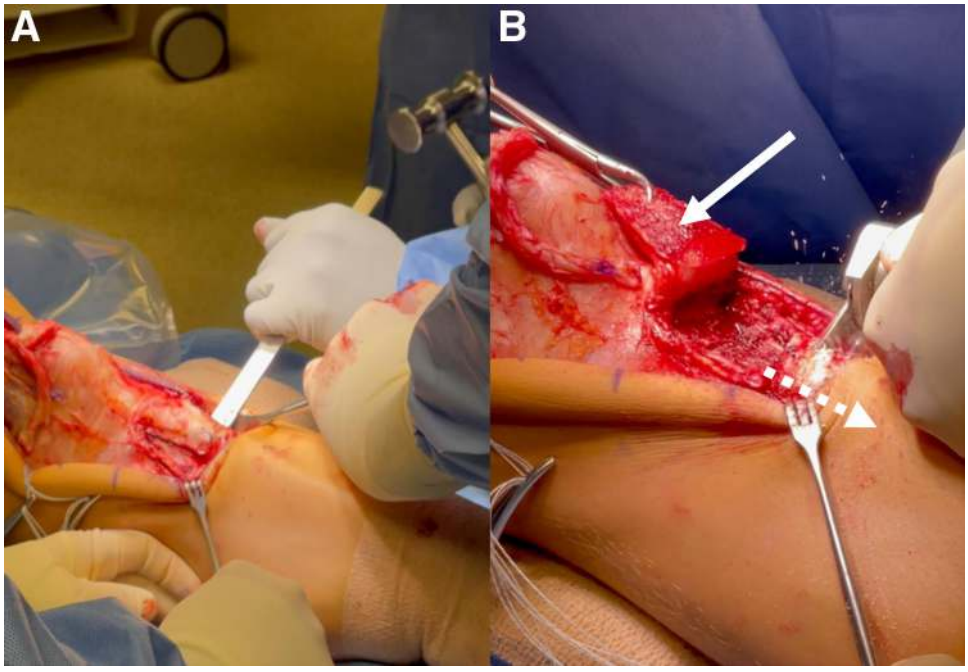

Fig 6. Tibial tubercle osteotomy. In patients with a tibial tubercle–trochlear groove distance greater than 20 mm, measured on axial computed tomography, medialization of the tibial tubercle may be indicated. Distalization of the tibial tubercle may also be used to decrease the height of the patella in patients with a Caton-Deschamps ratio greater than 1.4. (A) For the osteotomy, holes are drilled 2 to 3 mm apart with a 2-mm drill through the tibial tubercle and then connected with a small osteotome. (B) The tubercle is cut to a length of 3 cm (solid arrow) with a small anterior cruciate ligament saw. This saw is then used to excise 12 mm of bone distal to the tubercle (dashed arrow) for the distalization.

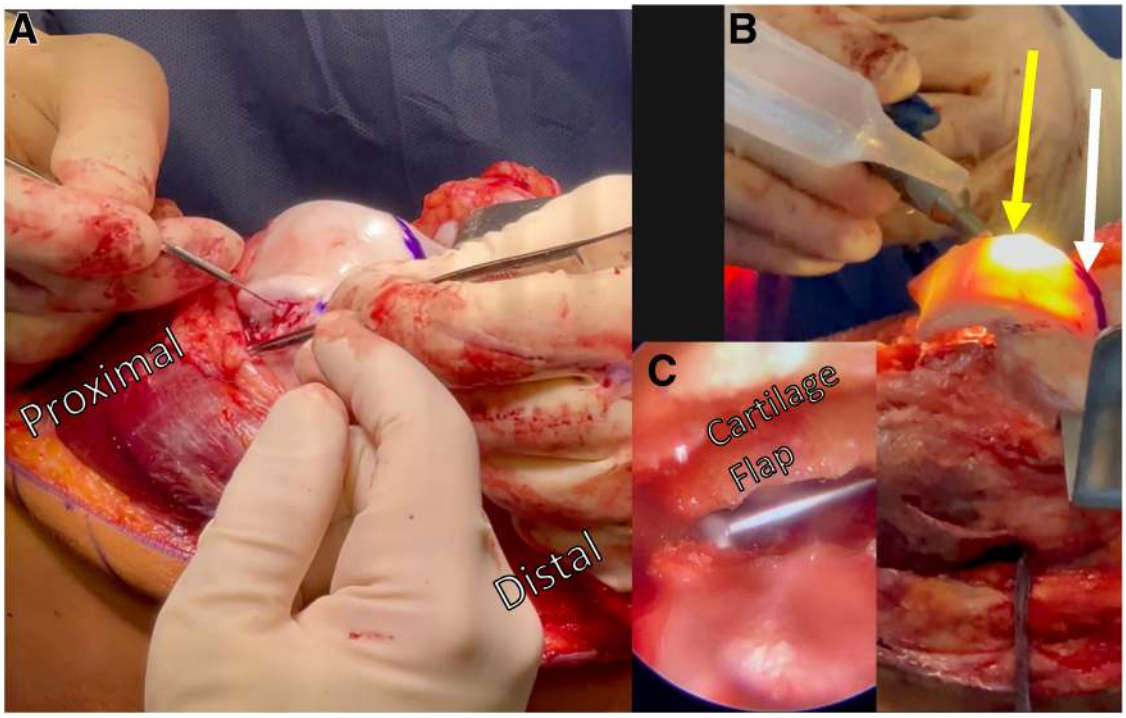

Fig 7. Trochleoplasty. Medial patellofemoral ligament reconstruction and sulcus-deepening trochleoplasty are indicated in patients with Dejour type B, C, or D trochlear dysplasia and a trochlear sulcus angle of 145° or greater. (A) First, a medial parapatellar arthrotomy is created, the distal femur is exposed, and the trochlear groove contours are outlined with a marker. A scalpel is then used to elevate the periosteum around the trochlear margins. (B, C) With abundant irrigation, a small burr is used to create a bone flap from beneath the cartilage margin to the trochlear groove (white arrow) outlined in blue. The flap should be thin enough to mold into the deepened V-shaped trochlea. The arthroscope can be inserted under the flap to ensure adequate clearance. The yellow arrow shows light from the arthroscope transilluminating the flap.

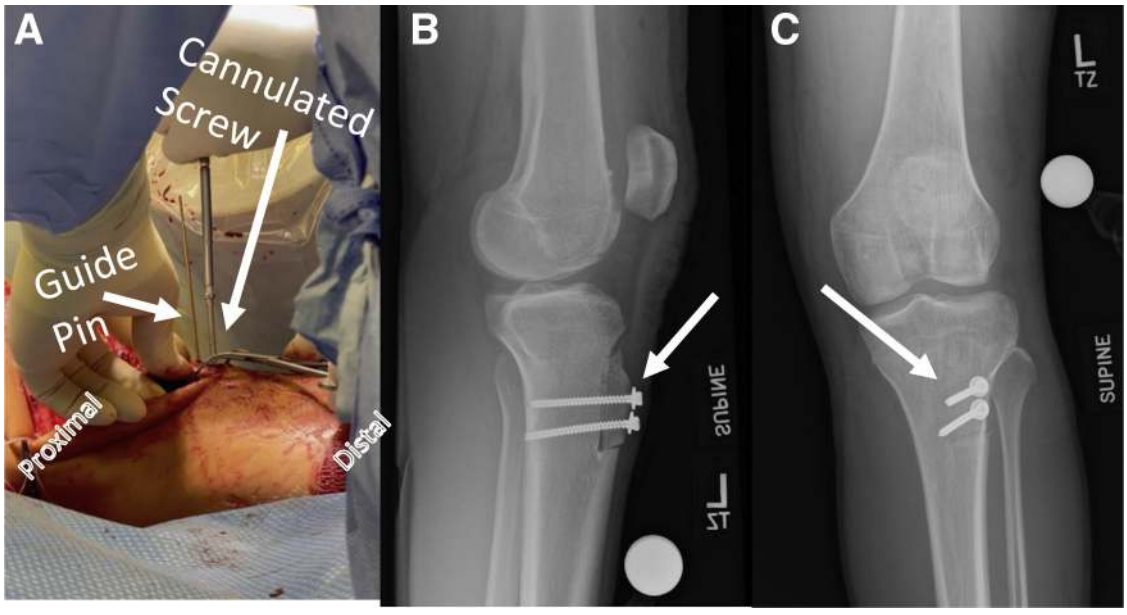

Fig 8. Intraoperative radiographs showing tibial tubercle osteotomy. In patients with patella alta and recurrent patellar dislocations, medial patellofemoral ligament reconstruction with tibial tubercle osteotomy and possible trochleoplasty is performed depending on the Dejour classification of trochlear dysplasia present, patellar height and positioning, integrity of the medial patellofemoral ligament, and lateralization of the tibial tubercle. To bring the patella back to an appropriate height and realign the extensor mechanism, a distalizing tibial tubercle osteotomy may be performed. (A) The tibial tubercle is reattached with 2 cannulated screws passed over guide pins. Lateral (B) and anteroposterior (C) radiographs taken intraoperatively verify the correct length and position of the screws (arrows) used for tibial tubercle distalization.

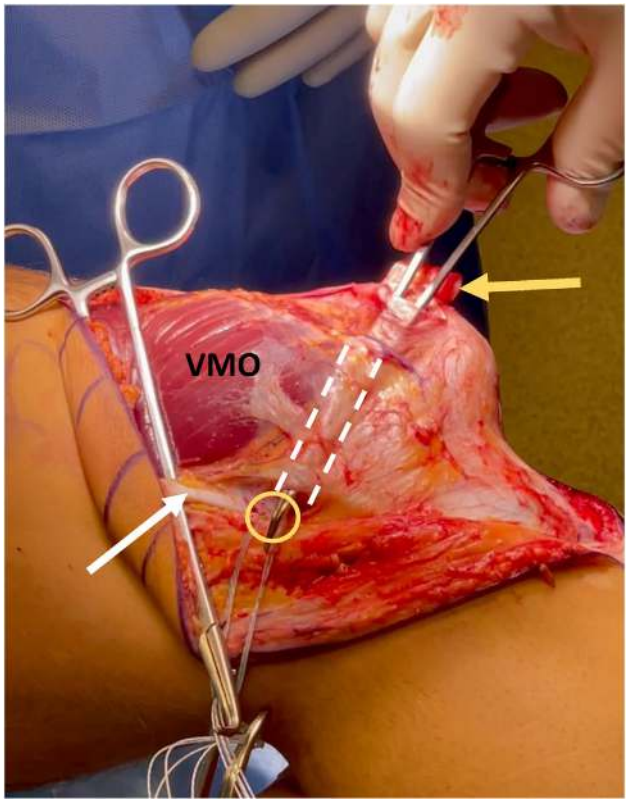

Fig 9. Medial aspect of left knee showing several aspects of medial patellofemoral ligament (MPFL) reconstruction. The MPFL accounts for much of the resistance to lateral displacement of the patella in extension and early flexion. Recurrent patellar dislocations may be due to—singly or in combination—trochlear dysplasia, over-lateralization or external rotation of the tibial tubercle, or MPFL injury. MPFL reconstruction may be accomplished with a quadriceps tendon graft (yellow arrow), passed through a channel beneath the medial retinaculum (white dashed lines). The adductor tubercle (within yellow circle) is located by following the adductor magnus tendon (white arrow, with instrument passed beneath tendon) along the distal edge of the vastus medialis obliquus (VMO) to its distal attachment on the femur. Here, Q-Fix anchors are affixed and used to secure the medial part of the quadriceps graft.

literature, with a study by Servien et al.[15] reporting a 94.5% satisfaction rate at an average of 5 years' follow-up of 135 distalization osteotomies with and without medialization. Yet, in a study reporting on a prospective cohort of 129 knees with recurrent patellar instability treated with either isolated MPFL reconstruction or both MPFL reconstruction and TTO, Mulliez et al. found no significant outcome difference at 1 year post-operatively.[16] Although additional long-term outcome studies reviewing the effectiveness of MPFL reconstruction, trochleoplasty, and TTO are required, we recommend our technique for treating recurrent patellar instability in patients with an insufficient

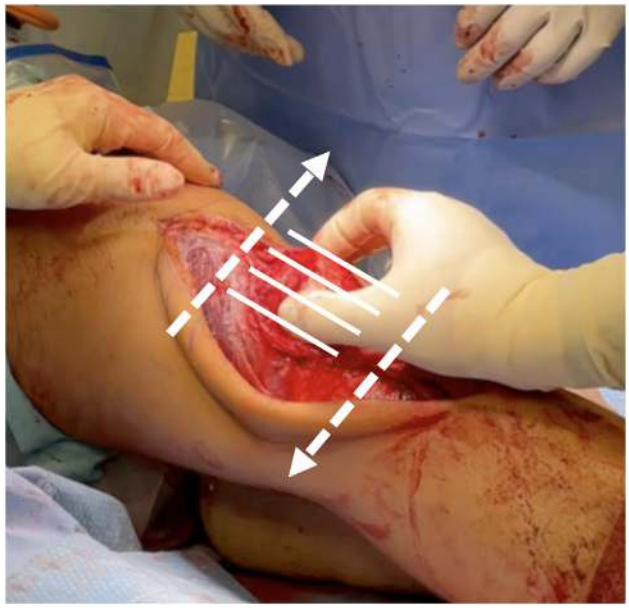

Fig 10. Medial and lateral patellar translation in left knee. The medial patellofemoral ligament serves as a major soft-tissue static restraint to lateral displacement of the patella. Medial and lateral displacement is measured in quadrants. To avoid overconstraining the patella, 1 quadrant of free movement is allowed after medial patellofemoral ligament reconstruction with the knee in extension. More than 2 quadrants is considered lax. The dashed arrows indicate medial and lateral movement; the solid lines indicate quadrants of patellar translation.

MPFL, a dysplastic trochlea, patella alta, and an increased TT-TG ratio.

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