Current Concepts Review

An Algorithmic Approach to the Management of Recurrent Lateral Patellar Dislocation

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➤ High-level evidence supports nonoperative treatment for first-time lateral acute patellar dislocations.

➤ Surgical intervention is often indicated for recurrent dislocations.

➤ Recurrent instability is often multifactorial and can be the result of a combination of coronal limb malalignment, patella alta, malrotation secondary to internal femoral or external tibial torsion, a dysplastic trochlea, or disrupted and weakened medial soft tissue, including the medial patellofemoral ligament (MPFL) and the vastus medialis obliquus.

➤ MPFL reconstruction requires precise graft placement for restoration of anatomy and minimal graft tension. MPFL reconstruction is safe to perform in skeletally immature patients and in revision surgical settings.

➤ Distal realignment procedures should be implemented in recurrent instability associated with patella alta, increased tibial tubercle-trochlear groove distances, and lateral and distal patellar chondrosis.

➤ Groove-deepening trochleoplasty for Dejour type-B and type-D dysplasia or a lateral elevation or proximal recession trochleoplasty for Dejour type-C dysplasia may be a component of the treatment algorithm; however, clinical outcome data are lacking. In addition, trochleoplasty is technically challenging and has a risk of substantial complications.

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The average annual incidence of primary patellar dislocation has been reported to be 5.8 cases per 100,000, and the rate is higher for younger and more active populations[1-3]. Dislocations can lead to articular cartilage injuries, osteochondral fractures, recurrent instability, pain, decreased activity, and patellofemoral arthritis[1,2,4-8]. Recurrence has been reported to range from 15% to 80%[1,9,10]. After a second dislocation, the chance of continued episodes of patellofemoral instability is >50%[1,4].

Recurrent lateral patellar dislocation is a multifactorial problem as patellar stability relies on limb alignment, the osseous structure of the patella and trochlea, and the integrity

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of static and dynamic soft-tissue constraints. The management of recurrent patellar instability is difficult for a number of reasons, including a heterogeneous patient population, a variety of technically challenging surgical techniques, and a lack of long-term and robust clinical outcome studies. The objective of this review was to provide an algorithmic guideline for treatment that may be applied in an individualized manner (Fig. 1).

Clinical Evaluation

The clinician should begin with a detailed history of the dislocation events. The age, skeletal maturity, sex, and overall activity level of the patient; the activity and position of the knee at the time of dislocation; and previous dislocation events should be carefully documented. Ongoing symptoms of pain should be localized and differentiated from weakness and instability. All prior treatments, including bracing, physical therapy, and surgery, should be reviewed. It is important to understand the patient's expectations for the return to sports, particularly for an in-season athlete.

General ligamentous laxity is assessed with the Beighton hypermobility score[11]. A valgus appearance on standing often results from limb alignment abnormalities, including increased femoral anteversion, hyperpronation of the foot, or external tibial torsion. This constellation of anatomic variances was termed "miserable malalignment" syndrome by James et al.[12] and is often associated with patellar instability. Instability may manifest dynamically because of muscle imbalance or weak musculature[13]. A valgus thrust can generate an external rotation moment about the knee with laterally directed force across the patella[14]. The vastus medialis obliquus bulk should be evaluated and quantified. Range of motion and lower-extremity strength should be compared bilaterally. A palpable defect along the medial retinaculum or medial patellofemoral ligament (MPFL) may be appreciable. Tenderness over the MPFL origin, the so-called Bassett sign, is consistent with a ligamentous disruption[15,16]. Patellar tracking should be examined and a J sign noted[17]. Lateral glide of three quadrants of the patellar width is consistent with hypermobility but must be accompanied by apprehension and asymmetry compared with the contralateral side[14]. The moving patellar apprehension test as described by Ahmad et al.[18] is the most sensitive and specific for patellar instability.

Diagnostic Imaging

Imaging for recurrent patellar instability should begin with radiography. Standard anteroposterior weight-bearing radiographs of both knees and posteroanterior weight-bearing radiographs made with the knee at 45° of flexion aid in the assessment of the coronal alignment of the tibiofemoral joint and the presence of arthrosis. Standing long-leg anteroposterior radiographs should be made if there is any concern for coronal malalignment. The true lateral radiograph in 30° of knee flexion provides information regarding trochlear morphology, patellar height, patellar tilt, and the presence of arthrosis[19]. Numerous methods are available for measuring

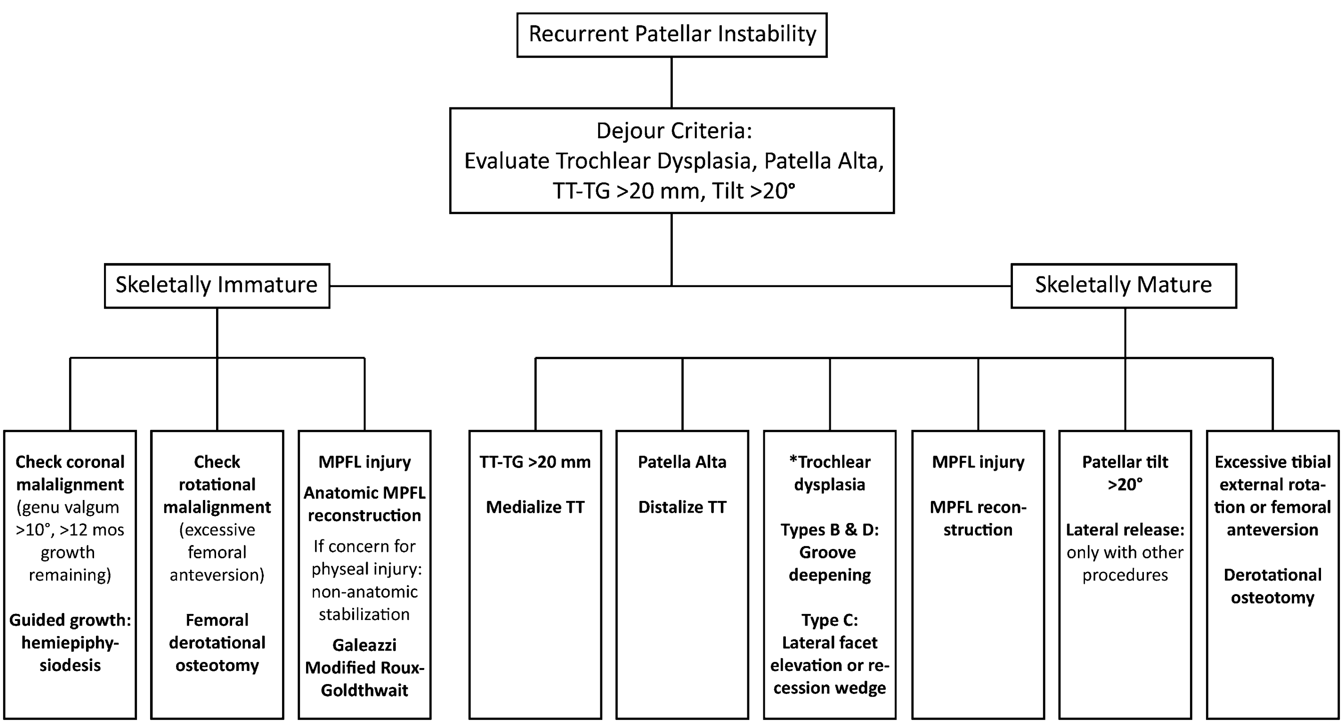

Fig. 1

An algorithmic approach for the treatment of recurrent patellar instability. The asterisk indicates that caution should be exercised when trochleoplasty is being considered, given the technical challenges and controversial clinical outcomes.

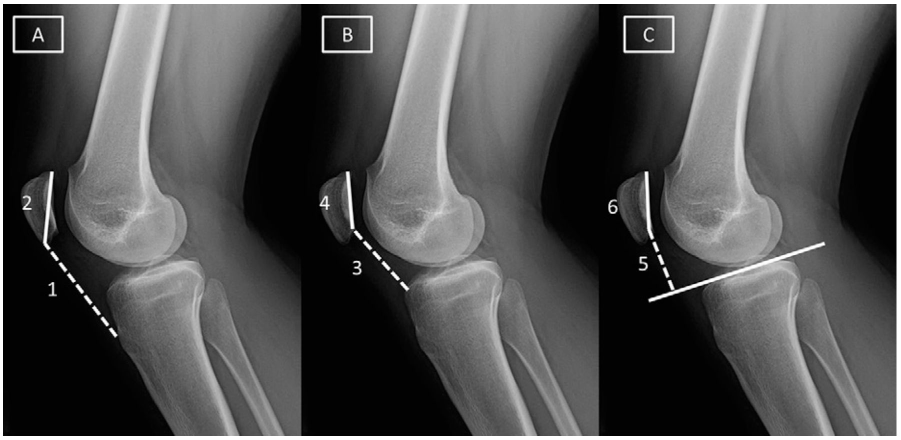

Fig. 2

Figs. 2-A, 2-B, and 2-C Representative radiographs with the indices for measurement of patellar height[19,20]. **Fig. 2-A** The Insall-Salvati index is calculated by dividing the length of line 1 by the length of line 2. **Fig. 2-B** The Caton-Deschamps index is calculated by dividing the length of line 3 by the length of line 4. **Fig. 2-C** The Blackburn-Peel index is calculated by dividing the length of line 5 by the length of line 6.

patella alta[19,20] (Fig. 2). True lateral radiographs may also identify trochlear dysplasia by the crossing sign, evidence of a supratrochlear spur, and a double contour, which denotes a hypoplastic medial condyle. The aforementioned trochlear findings were elucidated by Dejour and Le Coultre and were subsequently revised to create the trochlear dysplasia classification system[21,22] (Fig. 3). The Merchant view, made with the knee flexed 45° and the beam inclined 30° distally[23], is used to assess patellar tilt, patellar subluxation, and trochlear dysplasia.

In general, cross-sectional imaging is used for recurrent dislocations and/or once the decision is made to pursue operative interventions. In pediatric patients, the threshold for advanced imaging may be lower as osteochondral injury that is amenable to fixation occurs frequently after acute patellar dislocations[24]. High-resolution, axial, computed tomographic (CT) images may more accurately characterize the morphology of the trochlea and assess femoral and tibial torsion. If there is concern about the risk of radiation exposure with CT scanning,

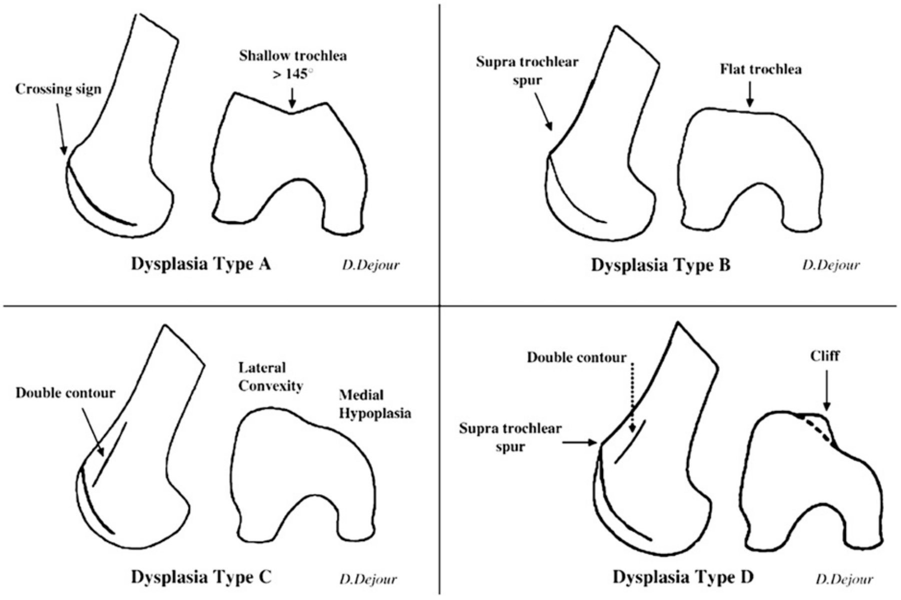

Fig. 3

Dejour classification of trochlear dysplasia[21]. Type A indicates the presence of the crossing sign with a shallow trochlea of >145°. Type B indicates the presence of a supratrochlear spur and a flat or convex trochlea. Type C indicates the presence of a double contour sign with a hypoplastic medial femoral condyle. Type D indicates the presence of a supratrochlear spur and a double contour sign with a cliff pattern between condyles. (Reproduced, with permission of Lippincott Williams & Wilkins, from: Dejour D, Le Coultre B. Osteotomies in patello-femoral instabilities. Sports Med Arthrosc. 2007 Mar; 15[1]:39-46.)

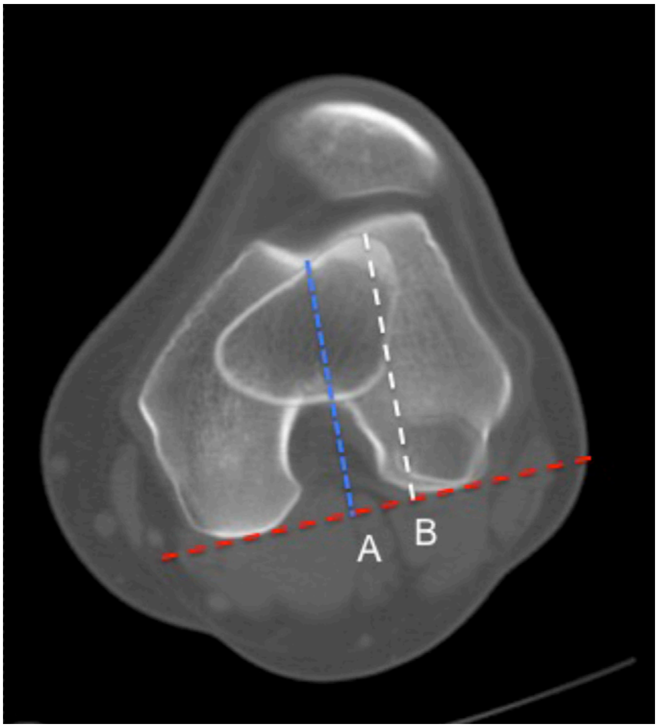

Fig. 4
Superimposed CT axial scans of the trochlear groove and the tibial tubercle demonstrating measurement of the TT-TG distance. Line A denotes the perpendicular to the deepest portion of the trochlear groove, and line B denotes the prominence of the tibial tubercle. The TT-TG measurement is the distance between lines A and B.

magnetic resonance imaging (MRI) will often suffice. Relative rotation is assessed via measurement of the tibial tubercle-trochlear groove (TT-TG) distance, which averages 8 to 10 mm in pediatric and adult patients as measured by CT or MRI (Fig. 4)[25-27]. A TT-TG distance of ≥20 mm is highly associated with patellar instability[25,28].

MRI is most useful for evaluating the soft-tissue restraints of the patellofemoral joint and the chondral surfaces. Standard MRI was compared with intraoperative findings and was found to be 85% sensitive and 70% accurate in detecting injury to the MPFL[29]. Studies have suggested that the MPFL is predominantly disrupted at the femoral origin, and thus the medial femoral condyle should be carefully evaluated for signs of acute or chronic changes associated with MPFL disruption[8,29-32]. With MPFL injury, adjacent soft-tissue damage, such as edema within the overlying vastus medialis obliquus or elevation of the vastus medialis obliquus off the medial femoral condyle, may also indicate injury[29,30]. Following acute injury, MRI can detect characteristic findings of a patellar dislocation, including cartilage damage that may be undetected on radiographs or bone bruising on the medial patellar facet and the lateral femoral condyle[24,33,34]. Concomitant cartilage injuries to the patellofemoral joint can be expected in 70% to 96% of knees with both acute and recurrent patellar dislocations[30,35-37]. MRI may also be used to assess patellar height by means of the patellotrochlear index[38], calculated as a ratio of trochlear articular cartilage to patellar articular cartilage on the MRI sagittal slice at the midline of the knee with the leg in extension. Values of <12.5% and >50% indicate patella alta and patella baja, respectively. The patellotrochlear index may be a more clinically relevant tool to measure patellar height in patients with trochlear dysplasia[39]. MRI-based estimates of TT-TG distance have been shown to underestimate the distance by an average of 3.8 mm compared with CT-based estimates[40]. Lastly, recent findings have suggested that trochlear dysplasia may be more accurately and reproducibly described as high grade versus low grade on MRI rather than by the Dejour classification on lateral radiographs[41,42].

Treatment

Nonoperative Management

High-level evidence supports nonoperative treatment for first-time lateral acute patellar dislocations[10]. There is also a role for physical therapy and nonoperative modalities in recurrent patellar instability if patients are informed of the redislocation risk and are within a sporting season with a desire to continue to participate. Therapy should consist of bracing or McConnell taping and gradual resumption of full motion and strength before the return to play[43,44]. Hinged knee braces or lateral stabilization braces may enhance the patient's sense of stability[45,46]. Physical therapy should focus on strengthening the vastus medialis obliquus and gluteal musculature in order to improve patellar stability[44]. However, most authors agree that the common indications for operative intervention are failure to improve with nonoperative treatment or recurrent patellar instability with (or without) secondary and progressive osteochondral injury[45,47-49]. Atkin et al.[50] reviewed their results at six months after nonoperative management and noted that, following an initial patellar dislocation, 58% of patients continued to have limitations with strenuous activity and 55% had not returned to sports.

MPFL Reconstruction

The most important restraint to lateral patellar displacement from 0° to 30° of flexion is the MPFL[51-53]. One advantage of reconstruction rather than repair is replacement of the torn or stretched ligament with a collagen-containing graft rather than imbrication of stretched or compromised tissues. Comparing MPFL reconstruction techniques, graft choice, graft positioning, or graft tension is difficult, given the paucity of clinical comparative studies. Furthermore, the procedure requires technical refinement as complication rates as high as 26% have been reported[54].

The femoral attachment of the MPFL has received much more scrutiny than the patellar attachment[55,56]. Given the precision necessary to appropriately place the femoral tunnel, our group has advocated for femoral tunnel position localization with anatomic landmarks followed by graft isometry and lastly with confirmation with radiographic parameters[56-59]. Recent studies have suggested that femoral tunnel malposition may result in graft anisometry, leading to graft laxity and ultimately

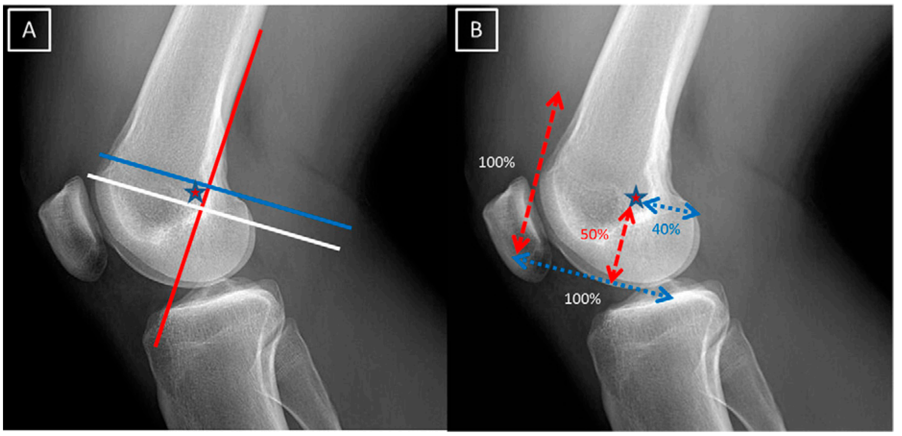

Fig. 5

Figs. 5-A and 5-B Medial patellofemoral ligament (MPFL) femoral origins are based on the Schöttle point and normalized dimensions. **Fig. 5-A** The Schöttle point (star)[59] is 1 mm anterior to the tangent of the posterior femoral cortex (red line), 2.5 mm distal to the perpendicular of the superior border of the femoral condyle (blue line), and immediately proximal to a perpendicular line from the superoposterior aspect of the Blumensaat line (white line). **Fig. 5-B** Normalized dimensions[56]: when the anterior-to-posterior diameter of the medial femoral condyle is considered to be 100% horizontally and the superior-to-inferior distance from the superior articular border of the patella to distal border of the femoral condyle is considered to be 100% longitudinally, then the MPFL femoral attachment site is 40% from the posterior, 50% from the distal, and 60% from the anterior borders of the medial femoral condyle (star).

early failure or excessive patellofemoral compression forces and ultimately arthrosis[55,60-67]. A femoral tunnel placed too far proximally may also lead to graft laxity in extension and excessive graft tension in flexion, which manifests clinically as anterior knee pain and loss of flexion[67]. Ultimately, repetitive flexion will attenuate the graft and lead to early failure and recurrent lateral patellar instability. A femoral tunnel placed too far distally will have a similar clinical result because of excessive graft tension in extension rather than flexion[67]. Radiographic guidelines developed by Schöttle et al.[59] and Stephen et al.[56] to aid in femoral fixation are depicted in Figure 5.

Additional factors for successful MPFL reconstruction are appropriate graft length and tension. The concept of graft isometry in MPFL reconstruction has been studied with varying conclusions[55,64,66-68]. Thaunat and Erasmus[67] introduced the concept of so-called favorable MPFL anisometry, or graft isometry from 0° to 30° of knee flexion, a range that is isometric in the native MPFL. This concept advocates for an MPFL graft that more closely recapitulates the native MPFL function by protecting against lateral patellar dislocation in extension where the graft is isometric and under tension. Graft tension can be measured intraoperatively; however, a more practical measure of graft tension is a comparison with the contralateral knee. Additionally, Koh and Stewart[48] suggested that the reconstruction should permit 1 cm of lateral translation in full extension or the equivalent of two quadrants of lateral deviation with a firm end point.

Several studies have demonstrated that MPFL reconstruction, specifically the placement of a femoral tunnel, is safe in a skeletally immature individual[59,69-72]. However, care must be taken not to disrupt the physis or perichondral ring with femoral tunnel or socket drilling[73]. If drilling cannot be accomplished safely, a slightly less anatomic MPFL reconstruction can be performed without drilling[74,75]. Suture anchors may be used rather than bone tunnels or sockets if there is concern for a potential physeal injury or iatrogenic fracture[76,77]. Nonanatomic distal realignment procedures have been described for skeletally immature patients with recurrent lateral patellar dislocation[78-82]. Despite success rates of >80%[78,81], the current trend in the treatment of recurrent patellar dislocation in skeletally immature patients is toward more anatomic procedures to minimize the risk of graft stretching and subsequent revision procedures after skeletal maturity[4,45,83-86].

A recent systematic review noted an overall complication rate of 26.1% in patients from six to fifty-five years old (average, twenty-four years). The most common adverse events included recurrent apprehension, arthrofibrosis, pain and clinical failure, and patellar fracture[54]. The complication rate may be lowered with appropriate postoperative rehabilitation, including cryotherapy to remove joint effusion, early mobilization to restore full range of motion, and progressive strengthening to prevent recurrent instability. Despite the numerous associated complications, most clinical studies have described retrospective data with 80% to 96% of the patients having a good or excellent clinical outcome[65,67,87-98]. MPFL reconstruction, alone or in combination, has demonstrated effectiveness following failed surgery for instability[92], and can provide stability and improved outcomes even in the presence of an increased TT-TG distance. No absolute cutoff value warranting an associated distal realignment procedure has been defined[99,100], so an increased TT-TG distance (>15 mm) may not be an absolute indication for medialization of the tibial tubercle during MPFL reconstruction[101,102].

Trochleoplasty

A renewed interest in trochleoplasty has occurred in response to the finding that 85% of individuals with recurrent patellofemoral instability have trochlear dysplasia[25]. Indications for trochleoplasty, which are being refined, include aberrant patellar tracking (identified by a J sign on clinical examination and a TT-TG distance of >10 mm[21]) and abnormal trochlear morphology (identified on a true lateral radiograph as overlap of the posterior condyles or on an axial MRI or CT scan[103]). To consider undertaking a trochleoplasty, the patient should have normal or nearly normal trochlear articular cartilage and have already undergone correction of any rotational malalignment. Several different trochleoplasty procedures have been described, but all are technically demanding[104-106]. The technical considerations for a deepening trochleoplasty include elevating a strip of cortical bone adjacent to the trochlea in order to remove underlying cancellous trochlear bone, thus deepening the trochlear groove, before reapproximating the overlying healthy bone and cartilage[107,108]. Schöttle et al.[109] examined the effect of raising an articular cartilage flap in a series of patients. The trochlear articular cartilage was examined using confocal microscopy and histologic evaluation at three, six, and nine months, and the authors concluded that, in a safely performed trochleoplasty, the articular cartilage remained viable in the short term. Further investigation is still warranted, given the cellular changes noted in the calcified cartilage layer[109]. The proximal resection or groove-deepening trochleoplasties have less risk of iatrogenic articular cartilage damage; however, they innately confer less stability[105].

Both surgeon and patient should be aware of the reported postoperative complications following trochleoplasty, and those specific to the procedure include iatrogenic cartilage damage, patellar incongruence, overcorrection, arthrofibrosis, and advanced arthrosis[103-105,110,111]. Given the technical demands and potential complications, it is not surprising that the clinical outcomes following trochleoplasty for recurrent instability are mixed, with satisfaction ratings ranging from 67% to 95.7%[103,106-108,112-116]. Currently, trochleoplasty should be reserved for surgeons with vast experience with these techniques and for patients with recurrent and complex patellofemoral instability.

Tibial Tubercle Transfer

The objectives of osseous distal realignment are to address the primary pathology, recurrent instability, which may be associated with patella alta and abnormal patellar tracking secondary to external tibial torsion relative to the trochlear groove. Medial tibial tubercle transfer (Elmslie-Trillat procedure)[117] and anteromedialization of the tibial tubercle (Fulkerson procedure)[118,119] have been described to meet these objectives in the setting of recurrent patellar instability[25,120-125]. The selected plane of the osteotomy needs to be individualized for each patient. A modified Elmslie-Trillat procedure in a 15° to 20° plane that medializes and corrects malrotation may be the most frequently used approach for patients with typical recurrent instability (Fig. 6)[126-128].

The indications for a distal realignment in the setting of recurrent instability include a TT-TG distance of >15 mm and a Caton-Deschamps ratio of >1.4[129-131]. Skeletal immaturity with an open tibial apophysis is a strict contraindication, given the risk of growth arrest and recurvatum deformity, and typically is not advised for patients younger than fourteen years[84,120,132]. A history of medial dislocations and patellofemoral arthrosis of the proximal and medial facets are relative contraindications. Chondrosis in these areas was more predictive of a poor outcome than the overall degree of arthrosis[124].

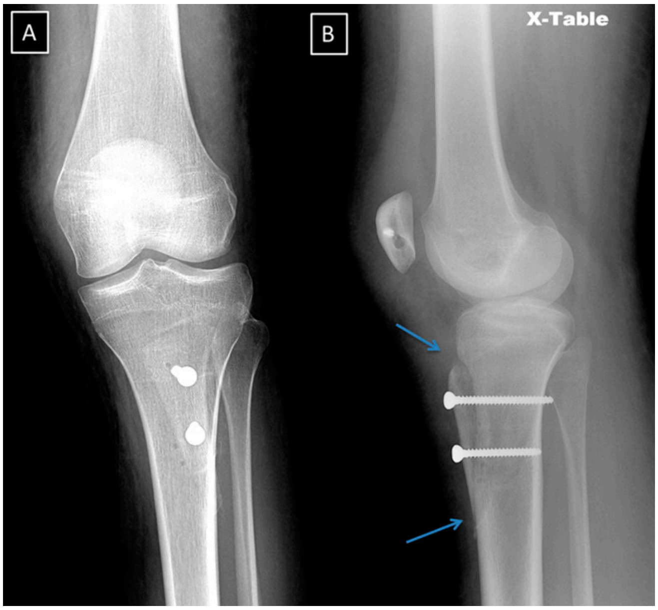

Fig. 6

Figs. 6-A and 6-B Tibial tubercle transfer technique. **Fig. 6-A** A long (>5 cm) and thick (>0.75 cm) osteotomy is performed to accommodate fixation with two screws. **Fig. 6-B** The obliquity of the osteotomy (blue arrows) is customized to address multiplanar malalignment; however, the osteotomy should be made in only one plane to avoid step-cuts, notching, and ultimately fracture propagation.

Isolated medialization of the tibial tubercle decreases the resultant lateral force vector acting on the patella and consequently increases patellofemoral stability. The preferred magnitude of medialization varies; however, the majority of researchers agree that postoperative TT-TG goals should be 9 to 15 mm[21,40,133,134]. To assess the adequacy of correction intraoperatively, the knee may be passively moved through a range of motion without signs of subluxation or dislocation. Care should be taken to ensure osseous contact between the osteotomized tibial tubercle and the triangular morphology of the proximal part of the tibia. Direct medialization has provided good-to-excellent patient-reported outcomes, with low rates of postoperative dislocation for patients with recurrent dislocation[120,135]. One concern with isolated medialization is over-constraining the patellofemoral joint, leading to patellofemoral arthrosis and subsequent long-term pain[122].

Modification to the initial uniplanar tibial tubercle transfers is the basis for anteromedialization, which combines the positive effects of the isolated medial and anterior transfers while minimizing the shortcomings[118]. A long osteotomy is performed to maximize the surface area and provide sufficient length for safe fixation with a minimum of two screws to control both rotation and translation (Fig. 6-A). The obliquity of the osteotomy is also customized to address the individual deformity, such that the degree of obliquity balances correction of the malrotation against the potential impacts of patellofemoral contact mechanics and chondral surfaces (Fig. 6-B)[114]. In cases of excessive external tibial torsion, a proximal tibial derotational osteotomy may be considered[99,100]. Osteotomies can be combined with MPFL reconstruction,

TABLE I Grades of Recommendations for the Treatment of Recurrent Patellar Instability

Condition*	Treatment*	Grade of Recommendation†
MPFL injury	MPFL reconstruction	C
Trochlear dysplasia	Trochleoplasty	C
Elevated TT-TG distance	Tibial tubercle realignment	C
Patella alta	Tibial tubercle realignment	C
Excessive femoral antetorsion (anteversion)	Femoral derotational osteotomy	C

*MPFL = medial patellofemoral ligament, and TT-TG = tibial tubercle-trochlear groove. †According to Wright et al.[154], grade A indicates good evidence for or against recommending an intervention (Level-I studies with consistent findings); grade B, fair evidence for or against recommending an intervention (Level-II or III studies with consistent findings); grade C, poor evidence for or against recommending an intervention (Level-IV or V studies with consistent findings); and grade I, insufficient or conflicting evidence not allowing a recommendation for or against intervention.

trochleoplasty, or lateral retinacular release as well as cartilage restoration procedures in cases of full-thickness defects, depending on the individual needs of the patient[99,100,136].

The overall complication rate following osseous distal realignment procedures has been reported to be 7.4%[133]. The majority of patients have symptomatic hardware, with ≥50% requiring hardware removal[137,138]. Fracture of the proximal part of the tibia, with a reported rate of 1% to 2.6%[133,139], may be prevented by ensuring that the osteotomy is at least 5 cm long by 0.75 cm thick and by avoiding step-cuts (Fig. 6-B)[137]. Isolating the clinical outcomes of distal realignment is difficult because most studies have experimental cohorts with patients who have multiple contributory factors for patellar instability and combined indications for tibial tubercle transfer. Concomitant procedures such as lateral release, MPFL reconstruction, and trochleoplasty are common[9,47,120,134,137,138,140,141]. Despite the limitations of the current literature, distal realignment procedures do result in low redislocation rates (0% to 15.2%) when performed for recurrent patellar instability[9,120,134,137,138]. Patient satisfaction following distal realignment was rated as good or excellent for 63% to 90% of patients[9,47,141].

Femoral Derotational Osteotomy

In addition to distal realignment procedures for a tibia-based deformity, unrecognized excessive femoral anteversion alters the forces across the patellofemoral joint, with a greater laterally directed force vector[142,143]. Such anteversion has been implicated in patellofemoral pain and recurrent patellar instability[52,144-146]. Investigators have described unrecognized excessive femoral anteversion as a cause of recurrent patellar instability and the etiology of the failure of initial instability treatment[25,54,146,147]. If rotational malalignment is suspected, advanced imaging with CT or MRI should be performed to quantify the deformity. Derotational osteotomy for excessive femoral anteversion (an anteversion of >20°) should be performed in patients with failed soft-tissue procedures or if all contributing osseous and soft-tissue factors are to be addressed concomitantly[136,146,148]. The osteotomy, if performed, should be done as close to the deformity as possible. It may be done proximally in the intertrochanteric region or distally in the supracondylar region; both options yield good-to-excellent results[148,149].

Algorithmic Approach with Graded Recommendations

The diagnostic pathway and treatment algorithm of our senior author (A.B.) does not advocate for a single treatment but rather provides a framework to ensure that important contributory factors are considered and potentially addressed (Fig. 1).

If nonoperative measures fail following a completed course of physical therapy and lateral patellar instability recurs, the surgical treatment is customized to the constellation and severity of soft-tissue and osseous pathoanatomy. In a skeletally immature patient (who is more than eight years old), coronal alignment should be assessed. If there is genu valgum of >10° with more than twelve months of growth anticipated, we perform guided growth with a tension-band plate across the distal femoral medial physis. If coronal alignment is adequate, excessive femoral anteversion may be addressed through derotational osteotomy. If both coronal alignment and femoral version are normal and the MPFL is injured, we advocate for an anatomic MPFL reconstruction. A lateral release may be indicated if patellar tilt is >20° and the patella cannot be everted to neutral on examination. If anatomic MPFL reconstruction may cause physeal injury, then a nonanatomic stabilization procedure should be performed.

In skeletally mature patients with recurrent lateral instability, we use the initial examination, radiographs, and advanced imaging to delineate patella alta, trochlear dysplasia, the TT-TG distance, patellar tilt, evidence of loose bodies or chondral damage, the integrity of the MPFL, and the location and/or severity of patellofemoral arthritic change. Our algorithmic approach is based on principles learned from the Lyon criteria[150] and the excellent work by Walch and Dejour[151], which considered systematically addressing the anatomy, including trochlear dysplasia, patella alta, patellar tilt, and increased TT-TG distance. Additionally, we advocate for an anatomic MPFL reconstruction in the setting of a disrupted ligament. If the patient has a substantially increased TT-TG distance secondary to external tibial torsion and/or patella alta, we combine the MPFL reconstruction with a distal realignment procedure. The osteotomy obliquity and need for distalization is customized and precisely defined on the basis of the severity of malrotation and patella alta and on an assessment of lateral and/or distal patellar facet chondrosis. A tibial tubercle transfer is not performed with the MPFL reconstruction in patients with patellar chondrosis of the medial facet or proximal pole because of the risk of compression overload. If there is Dejour type-B or type-D trochlear dysplasia, a groove-deepening trochleoplasty can be performed concomitantly. Dejour type-C trochlear dysplasia may warrant a lateral facet elevation, proximal recession wedge trochleoplasty, or groove-deepening trochleoplasty, although the literature is mixed and there is a lack of definitive evidence[101-114]. With all procedures, a lateral release can be added as a concomitant procedure in patients with radiographic patellar tilt of >20° with associated lack of eversion to neutral on examination. Excessive femoral anteversion should always be considered in patients with recurrent patellar instability, and a proximal, distal, or midshaft femoral derotational osteotomy (using an intramedullary saw and locked intramedullary nail fixation) and concomitant realignment should be performed. Lastly, in patients who have had failure after surgery for recurrent instability, both residual anatomic abnormalities and technical errors should be assessed and corrected.

The majority of investigators have recommended that recurrent lateral patellar instability should be addressed surgically[4,44-47,64,66,78,83,86-97,107,112,131,139]; however, there is no clear consensus on a consistent surgical algorithm. Furthermore, the available data are largely Level IV, with only a few recent Level-II and III studies[88,92,152,153]. As such, these recommendations for recurrent lateral patellar instability are graded C (Table I). Future investigations into recurrent patellar instability will benefit from prospectively collected, multicenter registry data with a coordinated effort toward uniform outcome measures and randomized clinical studies. It is only through multicenter prospective studies with a large sample size and uniform outcome measures, and thus a higher level of evidence, that treatment answers will be provided for patients with recurrent patellar instability. ■

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Update

This article was updated on May 11, 2016, because of a previous error. On page 421, in the legend for Figure 5-A, two of the lines identifying the Schöttle point were mislabeled. The sentence had previously read "The Schöttle point (star)[59] is 1 mm anterior to the tangent of the posterior femoral cortex (red line), 2.5 mm distal to the perpendicular of the superior border of the femoral condyle (white line), and immediately proximal to a perpendicular line from the superoposterior aspect of the Blumensaat line (blue line)." The sentence now reads "The Schöttle point (star)[59] is 1 mm anterior to the tangent of the posterior femoral cortex (red line), 2.5 mm distal to the perpendicular of the superior border of the femoral condyle (blue line), and immediately proximal to a perpendicular line from the superoposterior aspect of the Blumensaat line (white line)."

An erratum has been published: J Bone Joint Surg Am. 2016 June 15;98(12):e54.