Pediatric Orthopaedics

Patellar instability in children and adolescents

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ABSTRACT

Patellar instability is a common occurrence in the skeletally immature patient population, and multiple treatment options exist. Nonoperative treatment is appropriate for patients without osteochondral injuries and includes bracing and physical therapy focusing on strengthening of the gluteals as well as the vastus medialis obliquus muscles. Risk factors for recurrent instability include patella alta, trochlear dysplasia, and age younger than 25 yr. Isolated reconstruction of the medial patellofemoral ligament is indicated in patients with recurrent instability with normal tibial tubercle-trochlear groove distances with or without trochlear dysplasia. Distal realignment procedures risk physeal injury and are thus not routinely used in the skeletally immature population. Long-term data on the effect that trochleoplasty has on chondral surface have not been established and it has thus been a procedure reserved primarily for skeletally mature patient populations with chronic patellar instability. Despite multiple operative treatment methods, knee pain, decreased knee flexion, and recurrent instability are the most common postoperative complications.

Key Words
patellar dislocation, subluxation, children, adolescents

INTRODUCTION

Patellar instability is a complex, multifaceted condition that can be the result of soft-tissue injury or laxity, muscle imbalance, or even variations in bony morphology. It can lead to changes in normal knee biomechanics and may ultimately lead to chronic recurrent instability if not properly diagnosed and treated. Recurrence of patellar subluxation events is common and presents the treating orthopaedic surgeon with the challenge of determining whether patients should have nonoperative or operative treatment.

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EPIDEMIOLOGY

Prospective epidemiologic studies have determined the incidence of patellar dislocation to be 43 per 100,000 in patients younger than 16 yr of age.[1] The incidence of recurrent patellar instability after nonoperative treatment varies widely in the literature, ranging from 15-44%.[2] Fithian *et al.*[3] demonstrated that in patients with more than one previous dislocation or subluxation event, the risk of a subsequent event was 49%.[3] Furthermore, patients who were younger than 18 yr of age on their initial presentation had a high rate of a subsequent instability episode. Of those who do not have a recurrent dislocation, pain and mechanical symptoms may follow, with up to 58% reporting limitations in strenuous activity 6 mo after the initial dislocation event.[4]

RELEVANT ANATOMY

There are several layers of soft-tissue attachment that play an important role in stabilizing the patella. The medial patellofemoral ligament (MPFL) is the primary passive constraint to lateral displacement.[5,6] It originates in the groove between the adductor tubercle and the medial epicondyle as well as an oblique decussation of fibers off the proximal superficial medial collateral ligament.[5,7] Anatomic studies have found that the MPFL is on average 65.2 mm in length and that it originates on the femur an average of 10.6 mm proximal and 8.8 mm posterior to the medial epicondyle as well 1.9 mm anterior and 3.8 mm distal to the adductor tubercle.[8] This point, commonly referred to as Schöttle's point when viewed radiographically (Figure 1), has been described as being 1 mm anterior to the extension of the posterior cortical line, 2.5 mm distal to the posterior origin of the medial femoral condyle, and proximal to Blumensaat's line.[9••,10] These landmarks are useful when performing MPFL reconstruction to ensure anatomic placement of the femoral tunnel. The relationship of the MPFL and the distal femoral physis presents a technical challenge with respect to identifying the ultimate start point and trajectory for bone tunnels when performing MPFL reconstruction and will be discussed further in the operative treatment discussion.[11•]

The MPFL has a broad insertion on the patella, averaging 7.4 mm anterior to the articular surface and 5.4 mm distal to the proximal edge of the articular surface.[12] This insertion spans approximately 20 mm and is centered at the junction of the proximal third and distal two thirds of the patella along the total patellar length (proximal to distal).[12] Amis *et al.*[6] report that the MPFL provides 50-60% of the total restraining

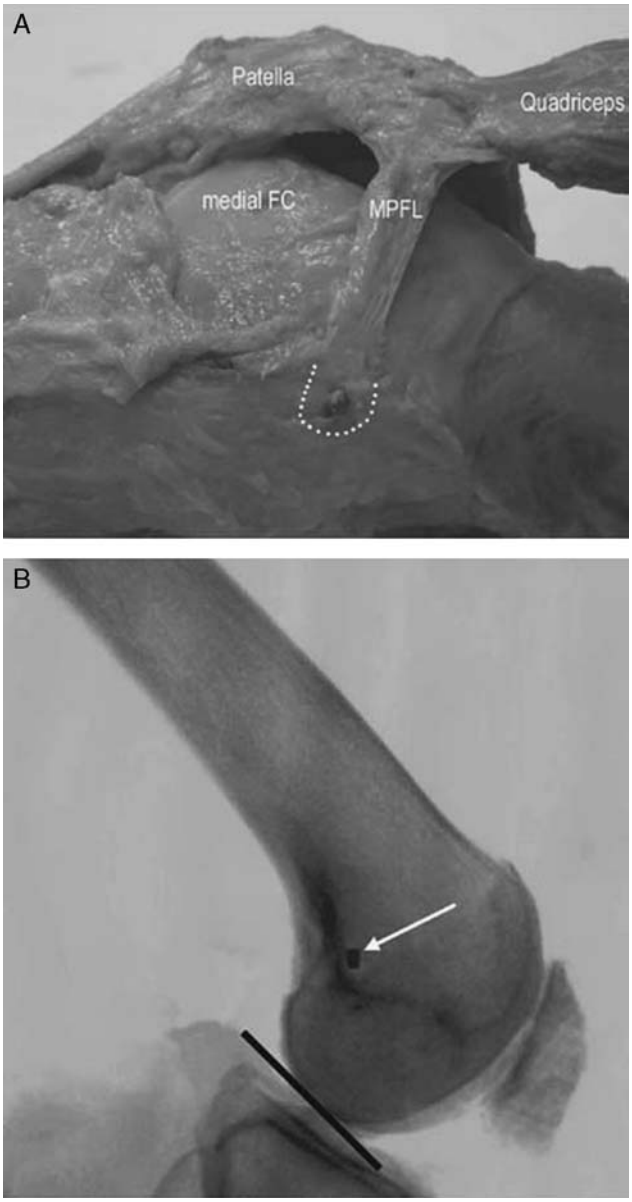

FIGURE 1. (A) Gross anatomy of the medial patellofemoral ligament (MPFL) with its femoral footprint (area marked with white points and lead ball). (B) Lateral view of the femur with the posterior condylar margin overlapped (black line) and the marked center of the femoral MPFL attachment (white arrow). (Reproduced from Schöttle *et al.*[9••]).

force against lateral patellar displacement. It is most taut in full extension and becomes lax as the knee flexes past 20-30 degrees and the patella engages the trochlea.

Laterally, the soft-tissue attachments have been divided into three layers. Superficially, there are contributing fibers from the iliotibial band that cause the patella to track more laterally. Additionally, there is an intermediate layer identified as the lateral patellofemoral band or the iliotibial patellar band that inserts along the midlateral patella. Finally, there are deep fibers that provide lateral constraints and are part of the knee capsule.[13]

The patellofemoral joint can be thought of as a sliding tongue-in-groove joint, with soft-tissue restraints that guide motion within the groove. Variations in the depth of the trochlear groove, the size and slopes of the patellar facets, as well as the length and integrity of the soft-tissue restraints all play roles in establishing and maintaining patellar stability.[14–16] Lewallen *et al.*[17••] demonstrated that in young patients with trochlear dysplasia the risk of recurrent dislocation after an initial event is 60-70%. Moreover, the Q-angle, defined as the angle formed between a line drawn from the anterior superior iliac spine to the central patella and a second line drawn from the central patella to the tibial tubercle, is greatest in the extended knee. The lateral facet of the trochlear groove is most prominent proximally and decreases in height distally and posteriorly. Once flexion is initiated, the soft-tissue constraints of the quadriceps and patellar tendons place a posteriorly directed force on the patella and provide increased patellar stability. As the knee bends, the contact pressure across the chondral surface of the patella moves from the lateral facet to the medial facet and from distal to proximal along the chondral surface.[18]

The peak of instability occurs with the knee in extension and lesser degrees of flexion and is due in part to the fact that the tongue-in-groove relationship is not engaged until approximately 20 degrees of flexion. In associated conditions such as patella alta, the trochlea is not engaged by the patella until higher degrees of flexion and is thought to contribute to the patellar instability.[19,20]

PHYSICAL EXAMINATION

After a thorough history has been obtained, a step-wise approach to diagnosing patellar instability should be taken. Keys to evaluation include examining the uninjured extremity for comparison followed by inspection of the knee for an effusion. After acute dislocation events, a hemarthrosis may be present as a result of an impaction fracture at the lateral femoral condyle or the medial patellar facet.[1,21,22] An inspection of the patient's stance and gait may reveal genu valgum, and additional measurement of the patient's Q angle should be performed with the knee in slight flexion to reduce tibial external rotation that occurs in terminal knee extension (screw-home mechanism).[23,24] The examiner must also remember that an unstable patella may naturally subluxate laterally resulting in an underestimation of the actual Q angle.

Palpation of the soft tissues on all four sides of the patella should proceed next. Superiorly, an effusion often is seen in the suprapatellar pouch if the dislocation event was recent. Pain may be present over the medial structures as far medial as the osseous attachment to the femur just cephalad to the medial epicondyle (Bassett's sign).[25] Lateral structures also may be tender, although medial subluxation events are more likely iatrogenic. Tenderness over the inferior pole of the patella may represent an associated finding of patellar tendinopathy.

Range of motion testing should be performed with special attention to the position of the patella as it approaches terminal extension. In patients with patellar instability, it may be observed that the patella moves from a central position within the trochlear groove to a more lateral terminal position as the knee transitions from flexion into extension. As the patella passes the lateral condylar ridge, this subluxation event might be recognized and is referred to as the J sign. Additionally, when the patient's knee is flexed to 20-30 degrees, a laterally directed force to the patella may induce a reflexive protective quadriceps contraction, observed clinically as a positive apprehension test. The moving patellar apprehension test, which has 100% sensitivity and 88% specificity, involves applying a laterally directed force on the patella to a knee that is being flexed concurrently by the examiner.[26]

Muscle bulk and tone should be documented with attention to the vastus medialis obliquus to determine if there is any disproportionate size or tone with respect to the vastus lateralis.[27] Furthermore, the strength of the quadriceps and gluteal muscles should be observed. Weak gluteal muscles may imply excessive femoral internal rotation and adduction and may contribute to instability.

Both varus and valgus stress examination of the knee also should be performed because there are fibers of the medial patellofemoral ligament that may be avulsed from the superficial medial attachment to the medial collateral ligament of the knee. Additional special testing can include patellar mobility to assess patellar tilt and patellar displacement. Patellar tilt testing assesses the amount of lateral tightness that exists while attempting to lift the lateral facet of the patella off the lateral femoral trochlea. Patellar displacement is recorded in terms of number of quadrants of displacement produced, with two quadrants representing roughly half the width of the patella. Finally, it is important to examine the knee for crepitus throughout the arc of motion. Early crepitus may indicate an inferior pole of the patellar chondral defect, whereas later crepitus may indicate a proximal lesion.

RADIOGRAPHIC EVALUATION

Standard posteroanterior and lateral weight-bearing radiographs as well as axial or Merchant radiographs are obtained during the initial assessment. The Merchant view is performed with the knee in 40 degrees of flexion and the beam inclined 30 degrees caudad.[28] The Merchant view allows assessment of the patellar tilt, patellar subluxation, and trochlear dysplasia. Patellar subluxation can be measured using the congruence angle, which is an assessment of the angle formed by the patellar articular ridge and the intercondylar sulcus and averages 6 degrees ± 11 degrees in the medial direction.[28] The sulcus angle is formed by the highest points of the medial and lateral femoral condyles and the lowest point in the intercondylar sulcus and averages 138 degrees ± 6 degrees. Trochlear dysplasia is indicated with a sulcus angle greater than 145 degrees.[29]

Lateral radiographs after an acute subluxation event often reveals an effusion. Evidence of a fluid/fluid level on lateral radiographs can serve as a clue that a lipohemarthrosis exists, which may indicate an associated osteochondral fracture.[30] Lateral radiographs with symmetric overlap of the medial and lateral posterior femoral condyles allow for assessment of patella alta using the Blackburne-Peel ratio, which has been shown to have increased interobserver reliability compared with the Insall-Salvati ratio.[31,32] For skeletally immature patients the Koshino and Sugimoto method for measuring patellar height can be utilized (Figure 2).[33]

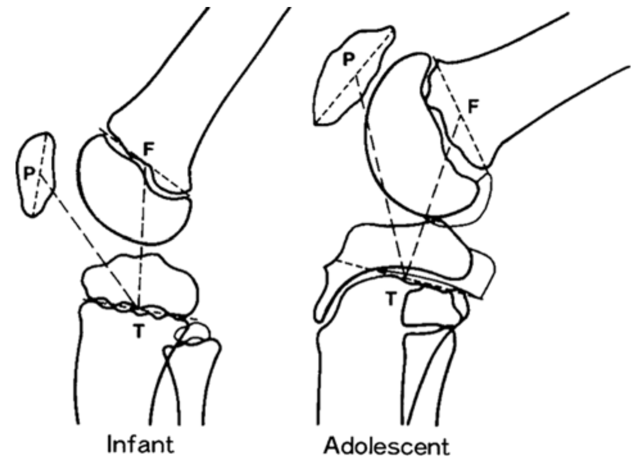

FIGURE 2. Koshino-Sugimoto method for assessing patella alta. F, T, and P are the midpoints of the femoral physis, tibial physis, and patella respectively. PT/FT from 0.99-1.20 is considered normal. (Adapted from Koshino and Sugimoto[33]).

The lateral radiograph also allows for further assessment of trochlear dysplasia and classification based on findings using a combination of axial and lateral radiographs. Type A dysplasia is characterized by a crossing sign on the lateral view and a shallow trochlea on the axial view. Type B dysplasia is characterized by a crossing sign and supratrochlear spur on the lateral view and a flattened trochlea on the axial view. Type C dysplasia is characterized by the crossing sign with a double contour on the lateral view, and medial hypoplasia on the axial view. Type D dysplasia is characterized by the crossing sign, double contour, with supratrochlear spur on the lateral view, and asymmetry of the trochlear facets on the axial view.[34]

Computed tomography imaging, specifically, axial images with superimposed slices of the tibial tubercle with respect to the trochlear groove, allows for measurement of the tibial tubercle-trochlear groove (TT-TG) distance. Ranges greater than 20 mm have been shown to correlate with patellar instability.[29] Dickens *et al.*[35•] recently reported the differences in TT-TG distances in children and adolescents based on age and found that the TT-TG distance varies with age.[35•]

MRI has been shown to be useful in assessing soft-tissue damage to medial structures, such as the MPFL, as well as identifying chondral injuries and loose bodies after traumatic dislocations.[36] Bone bruising also may be present and typically will present with lateral femoral condyle or medial patellar facet increased signal intensity on T2 and STIR imaging sequences (Figure 3).[37]

NONOPERATIVE TREATMENT

Goals of treatment include relief of symptoms, maintenance of knee range of motion, improvement of quadriceps strength, return to full activity, and prevention of future dislocation events. Studies have demonstrated redislocation rates from 15-44% for nonsurgical treatment.[2] Lewallen

FIGURE 3. (A and B) Axial proton density, fat suppressed, and T1 MRI sequences of a 13-year-old girl with recurrent patellar instability. Images demonstrate a medial patellofemoral ligament (MPFL) disruption with patellar subluxation, trochlear dysplasia, and increased signal within the medial portion of the patella. (C) Lateral radiograph after MPFL reconstruction.

et al.[17••] have demonstrated the risk of recurrence in first-time dislocators based on the presence of patella alta, trochlear dysplasia, and young age (Table 1), and this information may be helpful for patient counseling as well as guidance of treatment. Immobilization after an acute patellar dislocation is controversial, and there is no consensus on the role it plays in treatment programs. In a prospective randomized study performed by Palmu *et al.*,[38] 62 patients who had a patellar dislocation in the absence of intraarticular fragments were randomized to either nonoperative or operative treatment arms. Those patients with a dislocatable patella were given a removable knee extension orthosis (knee-immobilizer brace) for 3 wk and then transitioned to a patella-stabilizing orthosis. Those who did not have a dislocatable patella were given a patellar-stabilizing orthosis for 6 wk. Quadriceps muscle strengthening and full weight-bearing was started as soon as tolerated by the patient. Redislocation rates for nonoperative and operative cohorts were similar; 71% and 67%, respectively.[38]

Our institution follows a step-wise approach to nonoperative treatment similar to that previously described. Goals include reduction of swelling and early mobilization, followed by strengthening and proprioception improvement and ultimately early return to activities. Cryotherapy frequently is used initially to help control and reduce swelling with or without knee aspiration in patients with a large hemarthrosis. Patients are given a patellar sleeve and prescribed nonsteroidal antiinflammatory medication as well as formal physical therapy. Therapy exercises focus on improving quadriceps strength specifically in the early arc of motion when the patella is superior to the bony constraints of the femoral trochlea and at the mercy of soft-tissue constraints. Patients complete a rehabilitation program and then are allowed to return to sports after completion of the program. Criteria to return to sports include full range of motion, adequate quadriceps strength, and demonstration of appropriate function for their respective sporting activity.

OPERATIVE TREATMENT

Relative indications for operative treatment include: failure of appropriate nonoperative treatment; primary patellar subluxation with MRI evidence of an osteochondral defect; recurrent instability with radiographic evidence of increased tibial tuberosity to tibial groove (TT-TG) distance, trochlear dysplasia, or evidence of medial patellofemoral ligament (MPFL) disruption; and instability in high-level athletes or active duty service members. There are many described

TABLE 1. Risk of recurrence given presence of patella alta, trochlear dysplasia, and young age

Patella alta	Trochlear dysplasia	Younger than 25 yr	5-y Risk of recurrence (95% CI)
+	+	+	70.4% (54%, 80.9%)
−	+	+	60.2% (44.4%, 71.5%)
+	−	+	33.6% (20.8%, 44.3%)
+	+	−	29.6% (6.7%, 46.9%)
−	−	+	26.6% (17.1%, 35.1%)
−	+	−	23.3% (5.2%, 38%)
+	−	−	11.1% (2.1%, 19.3%)
−	−	−	8.6% (1.8%, 14.8%)

(Reproduced from Lewallen *et al.*[17••]).

techniques for treating patellar instability and no single gold-standard treatment method exists. There are multiple surgical considerations, and solitary procedures or combinations of surgical techniques can be utilized for treating patellar instability. Regardless of surgical technique, the operative procedure should begin by documenting an evaluation under anesthesia of both the operative as well as the nonoperative knee.

Lateral Release

Performing a lateral release as an isolated procedure to treat patellofemoral instability has been shown to be ineffective at preventing recurrent instability.[39] Furthermore, patient outcome scores from isolated lateral release procedures are not maintained after more than 4 yr of follow-up.[40] With this in mind, the role of a lateral release for the treatment of patellofemoral instability should be considered as an adjunct to other surgical options and avoided as an isolated solution. Coons and Barber[41] reported a nonrandomized case series of 53 patients and showed that arthroscopic medial thermal retinaculum shrinkage can be performed in combination with a lateral release with improved outcome scores and reduced recurrent dislocations rates of 9%; however, we have no experience with this technique and do not employ this method of stabilization as part of our treatment.

Distal Realignment

An increased TT-TG distance and increased Q-angle have been shown to contribute to patellar instability in both the adult and pediatric populations.[34] Skeletally mature patients with increased TT-TG distances often are treated with tibial tubercle medialization using various osteotomies. These procedures, however, risk physeal injury and are thus not routinely used in the skeletally immature population. Guided growth procedures including medial hemiepiphysiodesis are an attractive option for skeletally immature patients with genu valgum contributing to patellar instability.

The Roux-Goldthwait procedure, initially described in 1888 and modified in 1899, involves detachment and transfer of the lateral half of the patellar tendon under the intact medial half to the medial epiphysis. We have little experience with this procedure; however, Silanpaa *et al.*[42] reported an increased risk of osteoarthrosis and recurrent dislocation in patients undergoing a Roux-Goldthwait procedure when compared with those undergoing a medial ligament reconstruction.[42]

The Galeazzi procedure, described in 1922, involves tenodesis of the semitendinosis through a tunnel originating on the inferomedial portion of the patella. Letts *et al.*[43] reported good or excellent results in 88% of their patients; however, a recent study by Grannatt *et al.*[44] reported mixed results with 82% of patients experiencing recurrent subluxation and 35% requiring at least one additional surgery.

Medial Patellofemoral Ligament Reconstruction

A myriad of techniques have been described for MPFL reconstruction, among them free autograft or allograft reconstruction, using a hamstring autograft left attached distally and routed through the medial collateral ligament or around the adductor magnus, and use of a pedicled adductor magnus or quadriceps tendon graft. Our preference is for reconstruction with either a hamstring autograft or allograft placed into a socket on the femoral side and into sockets or attached with anchors at the medial patella.[45,46]

Goals for reconstruction should include avoiding damage to the physis that could result in physeal arrest or overgrowth (Figure 3). In a recent cadaver study by Shea *et al.*[47••] all subjects were found to have a MPFL footprint centered at or below the physis, with the proximal extent of the ligament above the physis in two older patients.[47••] Similarly, Farrow *et al.*[11•] performed a cadaver analysis of the MPFL attachment with respect to the distal femoral physis and found that in all 16 skeletally immature cadaveric specimens, the MPFL attachment was 8.5 mm distal to the medial femoral physis. Additionally, this study highlights the three dimensional nature of the distal femoral physis and demonstrates that drilling a bone tunnel directly lateral could result in damage to the concave portion of the distal femoral physis if drilled deeper than 10 mm. Starting the tunnel placement distal to the physis and directing the drill tunnel anteriorly may decrease the chances of injury to the distal femoral physis.[11•]

Nelitz and Williams[48•] recently described using a pedicled quadriceps tendon in skeletally immature patients to reconstruct the MPFL. The authors noted that advantages were avoidance of bony patellar complications, lack of chondral surface violation, cost savings, and truer anatomic reconstruction. Long-term outcome data are still pending.

Recurrent instability is a complication of MPFL reconstruction. Lind *et al.*[49••] analyzed 24 MPFL reconstructions and found that soft-tissue reconstruction using gracilis tendon looped around the adductor tendon insertion and inserted through drill holes in the proximal medial patella resulted in recurrent dislocation or subluxation in 20% and 25% of patients, respectively. The authors discussed possibilities for their results and hypothesized that securing the graft around the adductor magnus may provide less stability compared with fixation in femoral tunnels, which is usually used in skeletally mature patients. Failure to reproduce anatomic biomechanics in the knee after reconstruction also has been implicated in postoperative recurrent instability.

Fixation failure can occur after MPFL reconstruction as well. When assessing fixation methods for attaching MPFL grafts to the patella, Russ *et al.*[50•] showed that interference screw fixation was significantly stronger than suture anchor fixation in terms of ultimate failure load and stiffness. Failure in the suture anchor group was at the graft-suture interface, whereas failure in the interference group was at the graft-tunnel interface.

Cadaver analysis of the MPFL has revealed two separate functional bundles of the MPFL, which highlights functional differences in the anatomic relationship of the MPFL. Kang *et al.*[51] found two concentrated fiber bundles: an inferior-straight bundle that acts as the static restraint, and a superior-oblique bundle associated with vastus medialis obliquus (VMO) that acts as a dynamic soft tissue restraint. The length of the inferior-straight and superior-oblique was 71.78 ± 5.51 and 73.67 ± 5.40 mm, respectively. The included angle between bundles was $15.1 \pm 2.1^{\circ}$.[51] Due to the broad insertion site of the MPFL at the patella, Farr *et al.*[52] support the use of doubled semitendinosus allograft.

Lippacher *et al.*[53•] recently reported the results of 72 patients, including teenagers and older adolescents, undergoing MPFL reconstruction. They found that 100% of patients were able to return to sports with the caveat that only 53% returned at an equal or higher level. Seventy-nine percent of patients were satisfied or very satisfied. Recurrent instability was noted in 10% of patients and slight loss of knee flexion was noted in 24 of 72 knees. Another goal in improving patellar instability focuses on correcting patella alta. The effect of MPFL reconstruction on patellar height supports a decrease in patellar height postoperatively although long-term data are still missing.[54]

Trochleoplasty

Trochlear dysplasia is commonly associated with patellofemoral instability and is a risk factor for recurrent instability. This necessitates surgical consideration when addressing all contributing factors for instability.[55] However, there is no consensus on the role of trochleoplasty in the skeletally immature patient population and indications remain unclear. Banke *et al.*[56•] reported a prospective case series of 17 patients and 18 knees treated using combined trochleoplasty and MPFL reconstruction for the treatment of chronic patellar instability in adults and found that there were improved outcomes and normal apprehension tests at 2 years follow-up. However, there are still no data on the long-term effect that trochleoplasty has on chondral surfaces and it has thus been a procedure reserved primarily for skeletally mature patient populations with chronic patellar instability.

CONCLUSION

Patellofemoral instability is a common occurrence in the skeletally immature population and multiple treatment options exist. Despite the fact that most patients can return to recreational activities, there is still a large subset of patients that has recurrent instability and pain. Nonoperative treatment should be given strong consideration in the first time dislocator without osteochondral defect. Patients younger than 25 yr with radiographic evidence of patella alta and trochlear dysplasia should be counseled on the risk of recurrent dislocation. Multiple surgical techniques have been described with no single gold-standard technique identified. Continued research is needed to further understand the roles of combined surgical techniques in treating the underlying risk factors for patellar instability.

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46. Ahmad CS, Brown GD, Stein BS. The docking technique for medial patellofemoral ligament reconstruction: surgical technique and clinical outcome. *Am J Sports Med*. 2009; 37: 2021–2027.
47. Shea KG, Polousky JD, Jacobs JC, *et al*. The relationship of •• the femoral physis and the medial patellofemoral ligament in children: a cadaveric study. *J Pediatr Orthop*. 2014; 34:808–813.

This study reviewed six skeletally immature cadaveric specimens to better identify the relationship of the MPFL attachment relative to the distal femoral physis to help aid surgeons in MPFL reconstructions.

48. Nelitz M, Williams SRM. Anatomic reconstruction of the medial • patellofemoral ligament in children and adolescents using a pedicled quadriceps tendon graft. *Arthroscopy Techniques*. 2014; 3:e303–e308.

This surgical technique guide discusses using a pedicled quadriceps tendon to reconstruct the MPFL ligament. Advantages of the technique include avoidance of bony patellar complications, and anatomic reconstruction, a single incision, and sparing of the hamstring tendons for any future reconstructions.

49. Lind M, Enderlein D, Nielsen T, *et al*. Clinical outcome after •• reconstruction of the medial patellofemoral ligament in paediatric patients with recurrent patellar instability. *Knee Surg Sports Traumatol Arthrosc*. 2014. [Epub ahead of print].

This study evaluated children who underwent MPFL reconstruction and found that there were clinical improvements in knee function and pain following surgery, but found that patellar stability using femoral soft tissue graft fixation in pediatric patients was inferior to bony femoral fixation in adult patients.

50. Russ SD, Tompkins M, Nuckley D, *et al*. Biomechanical • comparisons of patellar fixation techniques in medial patellofemoral ligament reconstruction. *Am J Sports Med*. 2015; 43195–199.

This study found that interference screw fixation to the medial patella was significantly stronger than suture anchor fixation when comparing ultimate failure load and stiffness.

51. Kang HJ, Wang F, Chen BC, *et al*. Functional bundles of the medial patellofemoral ligament. *Knee Surg Sports Traumatol Arthrosc*. 2010; 18:1511–1516.

52. Farr J, Schepsis AA. Reconstruction of the medial patellofemoral ligament for recurrent patellar instability. *J Knee Surg*. 2006; 19:307–316.
53. • Lippacher S, Dreyhaupt J, Willams SR, *et al*. Reconstruction of the medial patellofemoral ligament. Clinical outcomes and return to sports. *Am J Sports Med*. 2014; 42:1661–1668.

This prospective review showed that of the 72 patients who underwent MPFL reconstruction, most were able to engage in regular sports activities 2 years postoperatively at a recreational level. Complications included pain, recurrent instability and loss of knee flexion.

54. Lykissas MG, Li T, Eismann EA, *et al*. Does medial patellofemoral ligament reconstruction decrease patellar height? A preliminary report. *J Pediatr Orthop*. 2014; 34:78–85.
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56. • Banke IJ, Kohn LM, Meidinger G, *et al*. Combined trochleoplasty and MPFL reconstruction for treatment of chronic patellofemoral instability: a prospective minimum 2-year follow-up study. *Knee Surg Sports Traumatol Arthrosc*. 2014; 22: 2591–2598.

This prospective case series of seventeen patients and eighteen knees treated using combined trochleoplasty and MPFL reconstruction for the treatment of chronic patellar instability in adults and found that there were improved outcomes and normal apprehension tests at 2-years follow-up.