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Treatment of Patellar Dislocation in Children

Introduction

Lateral patellar dislocation is a common knee injury in pediatric population[1], and is the most common acute knee injury in the skeletally immature. Over half of the cases cause recurrent patellar dislocations and pain. The mechanism of injury is most often with the foot planted and tibia external rotated. It can also occur with jump landing and/or decelerating. The medial patellofemoral ligament (MPFL) is frequently injured in an acute patellar dislocation.[2-7] Initial management of the pediatric patellar dislocation is mainly nonoperative. Surgery is indicated if a large osteochondral fragment is present or patella is highly unstable or extensively lateralized due to massive medial restraint injury. Surgical stabilization is recommended if redislocations are frequent and cause pain or inability to attend sports acitivites. Reconstruction of the MPFL is a preferred surgical option in the skeletally immature knee, as operations that involve bone are contraindicated. MPFL reconstruction techniques that do not involve drilling or disruption of the periosteum near the femoral physes are safe for the skeletally immature knee. Treatment of patellar dislocation in the skeletally immature patient is presented with specific discussion of surgical technique and results of double bundle MPFL reconstruction.

Epidemiology and predisposing factors

A population-based study have estimated annual incidence rate of first-time (primary) patellar dislocations in children,[1] resulting in 43 / 100 000. Buchner et al[11] reported a 52% redislocation rate in patients aged <15 years compared with 26% for the entire group. Similarly, Cash and Hughston[12] showed a 60% incidence of redislocation in children aged 11-14 years compared with 33% in those aged 15-18 years.

The potential risk factors for primary patella dislocations include trochlear dysplasia, patella alta, increased tibial tubercle–trochlear groove (TT-TG) distance as measured by axial computed tomography (CT) or magnetic resonance images, and patella tilt.[9] Risk factors reported for recurrent patella dislocation after primary dislocation include a young age at the time of the primary dislocation, the female sex, and dysplasia of the patellofemoral joint.[1,9,10]

In a natural history study after an acute patella dislocation, 189 nonsurgical patients were prospectively followed up for
2-5 years. The risk of an acute patellar dislocation was highest among females aged 10-17 years, and patients presenting with a history of instability were more likely to be female.[8] In a systematic review of first-time patella dislocations,[16] 70 articles containing information on the diagnosis and treatment of first-time patella dislocations were reviewed. In this review, the male-to-female ratio was nearly equal with the distribution of 46% males and 54% females. The average age was 21.5 years. Therefore it seems that children and young adults are at highest risk to have subsequent dislocations after primary injury.

Initial Management of acute patellar dislocation

Clinical findings and physical examination

Hemarthrosis of the knee is nearly always present in primary patellar dislocation. Sometimes acute patellar dislocation is associated with other knee injuries, such as anterior cruciate or medial collateral ligament tears, if the trauma energy is extensive.[17] Patellar dislocation may sometimes occur without significant swelling, in a case of severe trochlear dysplasia or tissue hyperlaxity syndrome. Also recurrent injury may not cause extensive hemarthrosis or soft tissue tenderness, if there is low trauma energy involved. However, aspiration of the knee is recommended for patient comfort in almost every traumatic dislocation. The physical examination includes apprehension test to lateral patella translation, often accompanied by pain and difficulty with any active quad activity (straight leg raising, active range of knee motion). Examination of tibial-femoral knee ligaments is necessary to rule out other severe ligamentous injury. If the injury is associated with significant external trauma energy and the patella needs to be manually reduced, knee flexion (to 90°) should be tested to confirm visual patellar positioning in the trochlear groove. If patella dislocates with every flexion arc, a significant injury to the medial restraints should be suspect, and likely requires initial operative intervention. A magnetic resonance imaging (MRI) is recommended to confirm injured structures.

Radiographs and MRI

Plain radiographs should always be obtained, including an anteroposterior, true lateral, and an axial knee view. Though many different radiographic axial techniques are described, [18,19] a view in early flexion is most helpful and more comfortable for the patient. From these multiple radiographic views, one can evaluate for associated risk factors, including patella alta and trochlear dysplasia, as well as identifying the patella position with possible associated lateral patella translation and/or tilt. Sometimes large osteochondral fractures can be seen, though chondral damage without an associated bony fragment will not be identifiable on plain radiographs. Given the high percentage of associated cartilage injury in addition to MPFL injury,[7,20-22] MRI scan has been recommended in patients who have acute patella dislocation. It has been shown that by using MRI, the MPFL disruption or primary injury location can be visualized.[21,23] On MRI, the disruption can be visualized as complete, if fibers in the expected region of the MPFL are completely discontinuous or appear absent with extensive surrounding edema.[23] Sometimes more than 1 injury location can be seen,[7,23,24] especially in midsubstance tears. This may represent partial discontinuity, suggesting MPFL elongation rather than a total disruption. However, the competency of the remaining ligament can be questioned.

Nonoperative management

According to a recent prospective, randomized study in adults, knee immobilization after primary traumatic dislocation is not recommended.[14] There is no consensus on initial management of acute patellar dislocation in children.[25] Traditionally options range from complete immobilization in extension for 2-4 weeks to immediate full motion and weight bearing as per patient comfort and function. The method of immobilization in adult patellar dislocation has been studied by Mäenpää and Lehto,[26] who compared treatments using a posterior splint, cylinder cast, or patellar bandage/brace. The cast and splint were worn for 6 weeks. The posterior splint group had the lowest proportion of knee joint restriction, lowest redislocation frequency per follow-up year, and fewest subjective complaints at final follow-up.[26] Although the results of that study supported immobilizing, it was seen in the recent prospective study[14] that most likely the immobilization is not needed to stabilize patella but brief period may be good for patient comfort.

Even though no studies have described the efficacy of physical therapy in the treatment of patellar instability, there is agreement on basic principles. Ambulatory aids should be used until a normal gait pattern is possible. Control of knee swelling and return of knee motion are initial concerns, followed by return of muscle strength. Rehabilitation needs to be directed toward recovery from injury as well as restoring potential pre-existing muscle imbalances, including strength and flexibility. Particular attention should be directed at core strength, targeting proximal control of limb rotation and balance. Exercises should challenge the patient without increasing pain and/or swelling. Full return to activities should be based not solely on objective physical examination parameters about the knee, but should include paced advancement of more challenging physical activity with some form of functional muscle assessment before release to full sports activities.

Operative management

Indications for initial surgical management of patellar dislocation in children include a large osteochondral fracture suitable for fixation and a highly unstable patella that dislocates with every flexion arc. In that case, a significant injury to the medial restraints should be suspected, and likely requires initial operative intervention. A preoperative MRI is recommended to confirm injured structures. In a patient with an acute first-time patella dislocation, repairing the MPFL when an isolated lesion can be localized seems prudent when one has to stabilize an osteochondral fracture of either the patella or trochlea. An avulsion at the MPFL insertion at the femur may warrant surgical intervention, as this injury is associated with a high rate of failure when treated nonoperatively.[21] However, there is no outcome data published on the MPFL repair back to the femur or patella in children.

Surgery for chronic patellar instability in the skeletally immature

Medial patellofemoral ligament

The MPFL has been described as the most important medial restraint against lateral patellar displacement.[5,27,28] MPFL acts as a check rein between the medial femoral condyle and the patella. The MPFL is a vertically oriented extracapsular structure, found in layer 2 of the 3 layer description by Warren and Marshall.[29] It attaches to the femur 5-10 mm proximal and 2-5 mm posterior to the medial epicondyle,[30] in the saddle between the medial epicondyle and the adductor tubercle. The adductor tubercle is a readily palpable bony prominence and a more discrete anatomical point, and may be a preferred landmark for locating the femoral insertion of the MPFL during surgery. The MPFL attaches approximately 2 mm anterior and 4 mm distal to the adductor tubercle.[30] The width of the MPFL at the femoral insertion is approximately 10 mm.[20] The patella attachment of the MPFL is approximated at the junction of the proximal and middle thirds of the patella,[31] typically at the location where the perimeter of the patella becomes more vertical. With a mean width of 28 mm,[7,30] it is wider than its femoral attachment.

Indication for surgery

The goal of surgical stabilization of the patella is to prevent further lateral dislocations, while allowing return to a full and active lifestyle. The goal of an MPFL repair or reconstruction is to restore the loss of the medial soft-tissue patella stabilizer, which is injured and/or chronically lax due to recurrent patellar dislocations. One can surgically restore the function of the MPFL with an acute repair, a late repair, or a

reconstruction. Acute MPFL repairs (after first-time patella dislocation) have mixed success as reported in our current published data, if one uses repeat dislocation as an endpoint.[10,11,32] Few of the published reports have age ranges to include the skeletally immature patient, and none stratify findings to separate by age.
Late repair or imbrication of chronically lax tissue (delayed surgery or surgery after repeat dislocations) has a high failure rate, and is not recommended as best practice option at this time.[33,34] For those children who have repeat lateral patella dislocations after being compliant with an appropriate rehabilitation program, MPFL reconstruction is a surgical option increasing in popularity.[35] In the skeletally immature knee, the procedure should not violate distal femoral growth plate. The surgical technique chosen should avoid drilling or periosteal disruption at or near the distal femoral physis.
The potential functional (ligamentous laxity, muscular weakness, poor body mechanics) problems should always be addressed with a good rehabilitation program before consideration of surgery. Core stability exercises and muscular imbalances of the lower limb should be thoroughly evaluated and addressed both in walking and running, to manage the problem before surgery. The clinician should be careful to exhaust nonoperative management to help control these episodes before suggesting a surgical solution.

MPFL reconstruction in children

An examination under anesthesia can be used to document excessive medial laxity (excessive lateral patella translation) without guarding or apprehension. Arthroscopy is useful to stage articular cartilage lesions, though MRI detection is preferable if cartilage repair is not required. Arthroscopy typically shows excessive lateral patella tilt and translation due to medial retinacular laxity with the joint distended. An arthroscopy can performed using both anterior and superior arthroscopic visualization portals, to view the entire patella surface and observe passive patella tracking. The superomedial or superolateral position of the arthroscope is helpful in observing passive patella tracking.

When the patella is near full extension, proximal to the deepening of the trochlear groove, the major restraints to patellar displacement are the soft tissues, particularly the MPFL.[5,27,28] As the knee flexion progresses, the major restraint to patellar displacement is femoral trochlear geometry, particularly the lateral wall of the trochlea.[37-39] The goal of the reconstructed graft is to allow the patella to enter the trochlea smoothly in early flexion, without medial patella facet overload in deeper flexion. The ideal length change behavior (isoanatomic length) for an MPFL graft has not been established, though how the graft should behave during knee flexion is reported in both in vitro studies and modeling studies.[39-43] Avoiding overconstraint of the graft is very important. After the graft is fixed, one should observe the arc of passive knee motion, particularly in early flexion. When the patella is manually displaced laterally at 0° of knee flexion, there should be laxity in the system with a firm end point (check rein). At 30° of knee flexion, one should have approximately 8 mm of lateral patellar translation with gentle manual force.[27,44] MPFL reconstructions in children with wide open physes offer additional complexities regarding graft fixation. Surgical procedures that avoid tunnel or screw fixation at or near the distal femoral physis are favored. Avoiding transverse patella tunnels and screw fixation within patella tunnels is ideal. Suitable techniques for patients with open growth plates include the adductor magnus (AM) tendon transfer,[3,45] the adductor sling technique,[46,47] and the medial collateral ligament sling technique.[48-50]

Results of MPFL reconstruction

In general, MPFL reconstructions achieve good postoperative patellar stability with redislocation rates < 4% in adults.[54] Outcomes-based clinical scoring instruments are generally favorable with high outcome scores. Studies on MPFL reconstructions in a dedicated cohort of patients with open growth plates are scarce in the current published data. Some of the published reports of MPFL reconstructions have age ranges to include also skeletally immature patients, but are lacking separate clinical results stratified by age.[3,48,55,56] One study of a large cohort of children used various surgical techniques, and the results included both MPFL reconstructions and repairs in acutely injured cases.[10] Results of surgical intervention in this study did not improve mid-term (7 year) outcomes, when matched against nonoperative management. Another published report on MPFL reconstruction in a small cohort of children (6 knees in 4 patients) with habitual patellar dislocation resulted in no patella dislocation recurrence after 4 years.[49]

Contraindications for MPFL Reconstruction

An MPFL reconstruction is not indicated for isolated patellofemoral pain. Physical examination must be consistent with laxity of medial patella restraint, and a history consistent with lateral patella dislocation must be elicited. Pain and "giving out" episodes are not sufficient criteria for establishing this diagnosis. An MPFL reconstruction is not indicated for excessive lateral patellofemoral tilt and/or translation on imaging, without history and physical examination evidence of recurrent lateral patella dislocations. The MPFL is not meant to "pull" the patella into position. Its role is to stabilize a located patella against excessive lateral force. The permanently dislocated or habitually dislocating patella, which dislocates in flexion, is due to a host of factors, including both bony and soft tissue components. Rotational and coronal plane deformities of the femur and tibia may need to be addressed in these cases in skeletal maturity. MPFL laxity is a result and not a cause of such an extreme alteration of the extensor mechanism. J-tracking is defined as a physical examination sign, where the patella appears to take the course of an inverted J during the initiation of early flexion. The patella begins lateral to the trochlea and suddenly moves medially, appearing to "hop" into the trochlear groove. The complete reasons for J-tracking are debated, but likely include both soft tissue and bony components. J-tracking can be well tolerated by children, and this physical examination sign alone, in the absence of other objective clinical signs and symptoms (knee swelling, repeated falling episodes), should not be an indication for surgical treatment. An isolated MPFL reconstruction is unlikely to eliminate patella J-tracking.

Surgical Technique of MPFL reconstruction: Adductor Magnus Transfer
By Petri Sillanpää

This technique is a double-bundle MPFL reconstruction technique, which can be used in skeletally immature patients. This is procedure builds on the original single-strand AM transfer technique, as previously published.[3,45] The patient lies in a supine position with both limbs exposed; access to the contralateral knee is recommended to give an opportunity to examine lateral patellar translation of the unaffected knee during the operation. A pneumatic tourniquet is used. A 3-4 cm longitudinal skin incision is made midway between the adductor tubercle and the medial patella margin, paralleling the proximal half of the patella. After blunt dissection in the subcutaneous tissue, the adductor tubercle is palpated. The superficial overlying fascia is incised, and the AM tendon is identified. With blunt dissection, the tendon is mobilized proximally. A graft harvester is used to harvest the tendon, keeping the distal insertion intact. The desired graft length approximates 14-18 cm, depending of the patient age and size. Graft length is determined by measuring the distance from the adductor tubercle to the medial edge of the patella; usually 14-18 cm is required for 2 bundles. The medial two-thirds of the tendon is used for the graft; because of anatomic variations of the AM tendon size at its distal insertion, it might be necessary to harvest the whole tendon. Ideally, some of the distal tendon would be retained, thus minimizing donor site morbidity (tendon insertion remains partially intact and muscle is not retracted). During tendon harvest, the harvester should direct the line of dissection medially, to avoid the branches of the saphenous nerve and perforating vessels that run from vastus medialis obliques (VMO) to the adductor canal of the thigh. The free end of the graft is sewn with a whipstitch, using an absorbable suture.

The distal insertion of the AM tendon is dissected free of adjacent tissues for ease in turning of the tendon 90° toward the patella; this turn is done on the most distal portion of the tendon as possible. The free end of the graft is passed through a tunnel created deep to the distal VMO and superficial to the joint capsule. This layer (layer 2[51,52]) is also the location of the original MPFL, and the patellar insertion of the MPFL can be visualized for assessment of correct patellar attachment. The patellar insertion of the graft is then made by passing the graft through the conjoined MPFL and VMO tissue, near the periosteum of the patella, at the proximal two-thirds of the medial patella. Thus, the free end of the graft emerges deep to the distal VMO in the periosteal region of the most proximal part of the medial patellar margin. This recreates the proximal MPFL bundle. The free end of the graft is then aligned parallel to the patellar medial margin, deep to the medial conjoined tissue near the patella periosteum. The distal bundle runs back to the adductor tubercle (Fig. 1). Suture anchors are placed in the medial patellar margin at the turning points of the looped graft. The graft is fixed with 2 suture anchors after a proper graft length, and tension is first checked to provide full knee flexion. Sliding of the graft in the soft tissue tunnels in repeated knee flexion cycles, adjusts the correct tightness of the proximal bundle individually, and then the patellar suture anchors are tightened. Thirty degrees of flexion position is used to fix the free end of the distal bundle near to the adductor tubercle with 2 periosteal number 1 nonabsorbable sutures. It is important to avoid overtightening of the graft; the degree of patella lateral displacement should be similar to the contralateral patella (if stable). After the distal bundle sutures are tied, the fascia, subcutaneous tissue, and skin are closed in layers. Additional procedures, such as lateral release are not indicated, if the patella can be medialized to neutral position in the trochlear groove.

Postoperative Protocol

Postoperatively, the patient is allowed to bear full weight as permitted by pain and quadricep muscle function. Knee flexion progresses to tolerance with 90° flexion usually achieved by 3-4 weeks. Quadriceps exercises are allowed immediately and closed chain exercises are encouraged. A knee brace is necessary for 2-3 weeks or until quadriceps strength is functional. Maximum load in daily activities is usually achieved by 8 weeks, with stair climbing in a tandem fashion being last to return. Return to full sporting activities depends on the sport and individual postoperative course. Return to presurgical muscle strength and stamina should be achieved before return to full play activity. This is typically at the 4 month mark.

MPFL Reconstruction Adductor Sling Approach: Surgical Technique By Elizabeth Arendt

A small incision (2-3 cm) is made along the medial border of the patella. The patella origin of the MPFL is identified, approximated at one-third of the longitudinal length of the patella measured from the superior patella tip. Fluoroscopy can be used to help locate the position in the dorsalventral plane; this is particularly helpful with the small kneecaps of the skeletally immature patients. The articular cartilage surface as well as the anterior patella cortex should be avoided; violating the anterior cortex increases fracture risk. A K-wire is passed through the patella medial to lateral, exiting the skin through a small stab wound at the lateral border of the patella. After appropriate patella position is found, the K-wire is overdrilled with a 3.5 or 4.5 mm cannulated reamer (depending on size of the graft). The length of the tunnel varies between 10 and 15 mm, 10 for a small patella (<35 mm in width) and 15 mm for most patellae. If a lateral retinacular lengthening is to be performed concurrently, a central incision can be made, and the K-wire exits within the central incision. A looped passer is placed through the patella medial to lateral. This loop passer can be a number 22 gauge wire looped on itself, a Hewson suture passer, or the looped passer from a biotenodesis shoulder set. A suture is threaded through the loop and passed lateral to medial through the patella. This looped suture will then pass the graft through the patella medial to lateral.

A semitendinosus or gracilis tendon is used as free graft. This can be either autograft or allograft. The technique of harvesting of the semitendinosus or gracilis is elsewhere described[53]

The ends of the free graft are secured on both ends with absorbable sutures, eliminating permanent sutures in the patella. The more tubular end of the tendon is marked according to the length of the patella tunnel.

The AM tendon is approached through a separate vertical incision. A 3-cm-long incision is made superior and slightly posterior to the medial epicondyle, ending at the medial epicondyle. The incision is made in line with the medial intermuscular septum. After through the fatty subcutaneous tissue, you will reach the adductor fascia. This is a very thin fascia in most patients. One makes a small incision through this fascia. Typically, finger dissection will most easily identify the AM tendon. The AM tendon can often be palpated before it can be seen. Anatomically, it sits flush to the posteromedial aspect of the femur, below the medial intermuscular septum, ending with its insertion on the adductor tubercle. Careful dissection around the distal AM tendon is necessary to free all interdigitations of the tendon to the surrounding soft tissue. Dissection down to the most distal aspect of the insertion assures that the graft lays as distal on the tendon as possible. A looped suture is placed around the adductor tendon for aid in graft passage.

The MPFL graft is first passed into the patella tunnel medial to lateral, pulling the graft until the appropriate graft length is well seated in the patella tunnel. Using the leader sutures, the graft is secured to the lateral retinaculum with a free needle, and the 2 sutures ends are tied to themselves. A second point of graft fixation to the patella is on the medial side; the graft is sutured to the cuff of medial retinaculum as it enters the tunnel at the medial border of the patella. This can be secured with box stitch of an absorbable suture.

The graft is then placed underneath the medial retinaculum, around the adductor tubercle tendon, keeping the graft horizontal under the adductor tendon insertion, crossing back over the graft. It is important to keep the vertical arm of the graft distal to the adductor tendon, as it better approximates the anatomic femoral insertion point of the MPFL. The graft is placed back underneath the medial retinaculum, and exits at the midmedial aspect of the patella.

With the graft is wrapped around the AM tendon, keeping the vertical arm of the graft distal to the tendon, one can cycle the knee in early flexion to estimate best angle of knee flexion for fixation. This will be based on the length change characteristics of the individual knee, but in most knees the optimal angle is between 30° and 40° of knee flexion. The knee is then bent to the desired degree of knee flexion, with the patella located centrally in the groove; the graft is tightened only enough to reduce redundancy. Where the 2 arms of the graft cross over one another, just distal to the adductor insertion, a single number 1 nonabsorbable stitch is placed across the 2 arms of the graft. At this point, the surgeon can test a full range of motion and passive patella translation. Passive patella motion should be tested following surgical principles discussed in an earlier section.

The distal arm of the graft is secured to the distal medial border of the patella with a soft tissue technique. The rectus femoris fascia on the dorsal surface of the patella is undermined. The graft is looped underneath this fascia and secured with a number 1 absorbable suture. Any excess length of the graft is excised. This is done at 20° of knee flexion.

Anatomical Risk Factors: When to Perform Additional Surgery

Increased quadriceps vector, measured by the physical examination sign of the Q-angle, is a well-known predisposing factor to patellar instability.[9] TT-TG distance, a radiographic measurement of the quadriceps vector, has been measured at_20 mm[9] in patients with recurrent patellar instability, whereas in the control group the TT-TG distance was 13 mm.

CT or MRI can be used to assess TT-TG distance.[9,57,58] How TT-TG measurement relates to the knee of (smaller boned) children is not known. MRI is a recommended imaging technique rather than CT imaging in the skeletally immature patients due to the absence of radiation exposure. Regardless of measurement scheme, how to accomplish reducing the quadriceps vector in children with open tibial apophyses is controversial. Historically, the Roux-Goldthwait procedure (detaching the lateral half of the patella tendon distally and reattaching it to a more medial location) is the most recorded procedure. However, it is hard to balance the 2 arms of such a procedure so that they carry equal or near equal force. This procedure can lead to attenuation and hypotrophy of the transferred limb, leaving a smaller and weaker patella tendon. Patella alta is also an associated risk factor for recurrent patella instability.[9] In children with open tibial physes, correction of patella alta can be accomplished by shortening of the patella tendon.[59]

Conclusions

First-time patellar dislocation is a common knee injury among the skeletally immature; progression to recurrent instability is variable but is reported in about 50% in select populations.[14,16,60] If nonoperative management has failed and instability compromises an active lifestyle and sports participation, surgery may be necessary. This article presents a technique for MPFL reconstruction that is safe in the age group with wide open physes. Though lacking prospective randomized comparison studies of different surgical techniques, an MPFL reconstruction is a minimally invasive surgical procedure with good early outcomes in adults, and a preferred surgical technique when surgery is warranted in this age group. There is some evidence that MPFL reconstruction may prevent progression of osteoarthritis when compared with traditional distal realignment procedures.[56,61] Prospective studies are needed to assess proper management of patellar dislocation, to avoid the potential adverse consequences of subjective joint instability complaints and osteoarthritis progression.

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