Original Clinical Article

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Modified Langenskiöld procedure for chronic, recurrent, and congenital patellar dislocation

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Abstract

Purpose Langenskiöld described a reconstructive soft-tissue procedure for irreducible lateral congenital patellar dislocations. Paley further detailed the technique in the surgical management of congenital femoral deficiency. The aim of this study was to evaluate the outcomes of patients with congenital, chronic and recurrent patellar dislocations treated with the modified Langenskiöld procedure.

Methods This is a retrospective case series. Between 2011 and 2018, 18 knees in 13 patients (mean age 15.8 years (SD 4.4; 12 to 29.9), nine female) with diagnoses of recurrent (six patients, eight knees), chronic (four patients, six knees) and congenital (three patients, four knees) patellar dislocations were treated with the modified Langenskiöld procedure.

Results There were no recurrent lateral dislocations in the congenital or recurrent groups. One of the patients in the congenital group had an overcorrection with some medial patellar maltracking but until this time has not required any further surgery. In the chronic group two of the six knees developed further dislocations; these were both on the same patient, who had no dislocations until one year after surgery. Mean Kujala score was 83.7 (SD 17; 47 to 100) for all groups. In spite of preoperative knee flexion contractures of up to 30° in three patients (six knees), all patients had full extension postoperatively. Eight patients reported being satisfied with their outcome, one was somewhat satisfied, two were very dissatisfied, and two did not respond.

Conclusion The modified Langenskiöld reconstruction provides a powerful correction for challenging cases of congenital and recurrent patellar dislocations. Re-dislocation as well as overcorrection can occasionally occur.

Level of Evidence: Level IV

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Keywords: Langenskiöld; dislocation; instability; patella

Introduction

The surgical management of congenital, recurrent and chronic patellar dislocations is an ongoing challenge and continues to evolve. Recurrent dislocations occur in 15-44% of patients following nonoperative treatment after an initial dislocation.[1] In certain situations, especially where there is an associated condition or malalignment, chronic dislocations can occur, in which the patella remains dislocated at rest. Other contributing factors can include coronal malalignment (excessive genu valgum), axial malalignment (excessive femoral anteversion and/or external rotation of tibia), patella alta, trochlear dysplasia, vastus medialis obliquus (VMO) pathology, severe ligamentous laxity (for example Ehlers Danlos or Down syndrome) or iatrogenic instability from prior procedures, all of which contribute to patellofemoral instability. Given the multifactorial pathogenesis and lack of reliable operative results in the treatment of congenital, recurrent and chronic patellar dislocations many surgical techniques have been described and the gold standard treatment has yet to be identified.[2]

Some techniques focus on rearrangement of the soft tissues (medial patellofemoral ligament (MPFL) reconstruction, VMO transfer, lateral release, quadricepsplasty etc), while others address bony structures (tibial tubercle transfer, trochleoplasty, derotational osteotomies etc). Vacariu et al[3] recently reported long-term outcomes in patients with recurrent patellar dislocations treated with the Green's quadricepsplasty. They reported a 53.8% re-dislocation rate and recommended against performing this procedure as a standalone technique. The Green's quadricepsplasty combines a lateral release, the transfer of the medial head of the quadriceps onto the lateral part of the patella and imbrication of the medial patellar retinaculum and joint capsule.[4] In 2014, Camathias et al[5] reported poor outcomes after Stanisavljevic quadriceps transposition for the treatment of congenital and recurrent patellar dislocations, with an 80% rate of re-dislocation. This procedure combines a patellar tendon transfer with a lateral release and medial plication and an extensive subperiosteal medialization of the entire lateral quadriceps.[6] In 2012, Efe et al[7] reported a 22% re-dislocation rate, 35% poor to fair results on the Kujala score and 27% dissatisfaction in 45 patients with recurrent patellar dislocations treated with Insall's proximal patellar realignment procedure.[8]

In 1992 Langenskiöld and Ritsilä[9] from Finland described this novel reconstructive soft-tissue procedure for irreducible lateral congenital patella dislocation and did not report any recurrent lateral dislocations. Langenskiöld's technique was further modified by Paley[10-12] as part of the surgical management of congenital femoral deficiency. Interestingly, recent review articles about recurrent patella instability do not even mention this technique.[2,13-19] As compared with the procedures mentioned above, the Langenskiöld procedure consists of patella medialization within the synovium, distal patellar tendon realignment, VMO advancement, lateral release and in the case of congenital patella dislocation with external rotatory subluxation of the tibia on the femur, lengthening of biceps femoris and iliotibial band. The procedure has not been popularized in treating other challenging forms of patellar instability. There are no other series since Langenskiöld's original publication reporting this technique for congenital dislocation of the patella. There are also no other series reporting on the outcome of patients with chronic and recurrent patellar dislocations treated with this technique.

The aim of this study is to determine if the modified Langenskiöld procedure, as detailed in this report, is able to achieve patellar stability, not only in patients with congenital patellar dislocations but also in patients with recurrent and chronic patellar dislocations.

Materials and methods

After institutional review board approval, a retrospective study was conducted from 1st July 2011 to 28th February 2018 at Loma Linda University Children's Hospital where all cases were performed. In total, 25 knees in 18 patients who underwent the modified Langenskiöld procedure were screened for eligibility (Fig. 1).

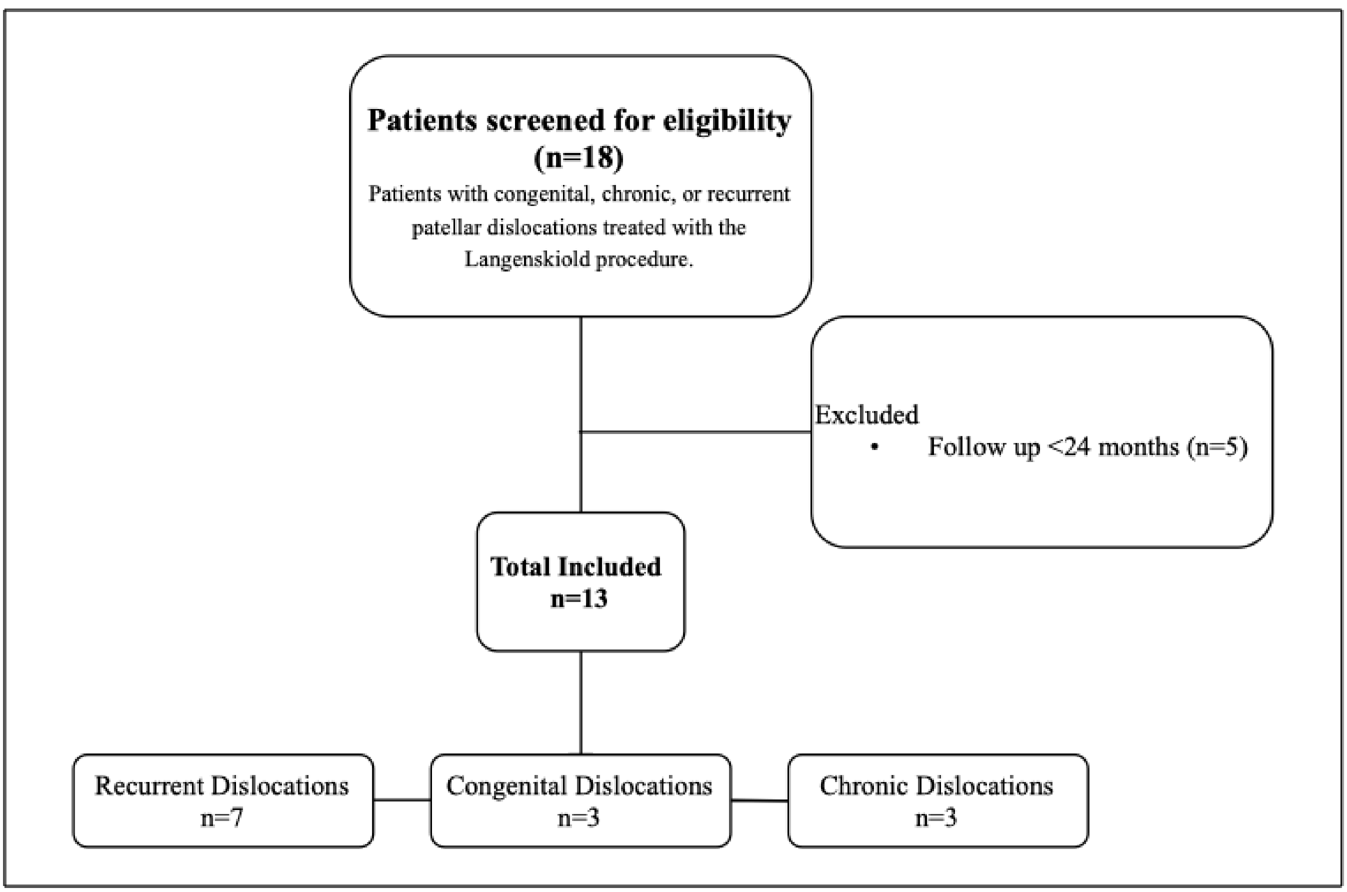

Fig. 1 Patient flow diagram.

Surgeries were performed by two paediatric fellowship trained orthopaedic surgeons (SN, MM). Informed consent was obtained from all the individuals participating in the study.

Patients were excluded if their follow-up was less than two years. Five patients were unable to be reached for follow-up. This left a total of 13 patients (18 knees) who met the eligibility criteria. The patients included in the study were divided into groups according to their diagnosis of recurrent patellar dislocation, chronic patellar dislocation or congenital patellar dislocation. Mean age was 15.8 years (SD 4.4; 12 to 29). Four patients (six knees) were male and nine patients (12 knees) were female. Mean follow-up was 4.7 years (SD 1.67; 2 to 9.4). Nine patients had their final follow-up in the outpatient clinic and four were only available by telephone. There were six patients (eight knees) with recurrent patellar dislocations, four patients (six knees) with chronic dislocations and three patients (four knees) with congenital dislocations. Chronic dislocation was defined as an irreducible dislocation present for more than three months. Two patients (three knees) had previous surgical interventions on the affected knee: one previous patella realignment surgery and two failed MPFL reconstructions. Table 1 summarizes the patients' characteristics.

Surgical technique

The patient is placed supine on a standard operating table. A bump may be used under the ipsilateral hip to prevent lower extremity external rotation. The entire lower extremity is prepped and draped to the groin. A sterile tourniquet is placed on the proximal thigh.

A longitudinal incision is made over the knee to expose the patella and extensor mechanism (Fig. 2). The location of the incision varies based on the original location of the patella and can be curved to end near the insertion of the patellar ligament as needed. Full thickness flaps are created with the subcutaneous fat. The VMO is identified and sharply isolated from the quadriceps tendon. The VMO and medial retinaculum are then sharply taken off of their insertions onto the superomedial patella leaving the synovium intact. The patellar ligament is then separated from the underlying synovium without entering the knee joint. This can be facilitated with a blunt retractor. The lateral retinaculum is then separated from the synovium laterally from inferior to superior up to the vastus lateralis and quadriceps tendon. These can be separated from the synovium in a similar fashion to the medial side, eventually releasing the quadriceps tendon from the synovium laterally. Ideally the synovium stays intact, and the knee joint

Table 1 Patient demographics, diagnoses and history

ID	Age	Sex	BMI (kg/m^2)	Laterality	Associated pathology	Previous surgeries	Comorbidities/other orthopaedic diagnoses
Congenital dislocations							
1	12	M	38.9	R/L	Trochlear dysplasia; generalized ligamentous laxity	None	Bilateral knee flexion contractures; Down syndrome, asthma
2	13	M	19.6	L	Femoral anteversion, trochlear dysplasia	None	DiGeorge syndrome, VSD
3	13	M	23.3	R	Genu valgum, Right femur hypochondroplasia	None	Hypochondroplasia, hearing impaired (hearing aid)
Chronic dislocations							
4	14	F	29.7	R/L	Genu valgum, femoral anteversion	Failed patellar realignment, bilateral	Anxiety (agoraphobia with panic disorder), depression, JIA, overweight
5	15	F	27.5	R/L	None	None	None
6	18	M	22.9	L	Genu valgum, generalized ligamentous laxity	None	Down syndrome, developmental delay, JIA, psoriatic arthritis, hypothyroid, diabetes mellitus type 1, celiac disease.
7	29	F	29.6	L	Myelodysplasia, Left knee extension contracture	None	Spina bifida L3, VATER syndrome
Recurrent dislocations							
8	13	F	40.3	L	Trochlear dysplasia, patella alta, genu valgum	None	Overweight, ovarian cyst, asthma
9	14	F	21.8	R/L	Patellar and trochlear dysplasia; generalized ligamentous laxity	None	Turner syndrome/ gonadal dysgenesis, migraines
10	14	F	19.9	R	Femoral anteversion, trochlear dysplasia, genu valgum; generalized ligamentous laxity	Failed MPFL reconstruction	None
11	16	M	16.7	R/L	Trochlear dysplasia, severe patella alta; generalized ligamentous laxity	None	Asthma, environmental allergies
12	17	M	28.4	L	Patella alta, trochlear dysplasia	None	Bipolar
13	17	F	27.5	L	Patella alta, genu varum	None	Mild scoliosis, proteinuria, obesity

BMI, body mass index; VSD, ventricular septal defect; JIA, juvenile idiopathic arthritis; VATER, vertebral abnormalities, anal atresia, tracheal anomalies, esophageal abnormality, renal problems; MPFL, medial patellofemoral ligament

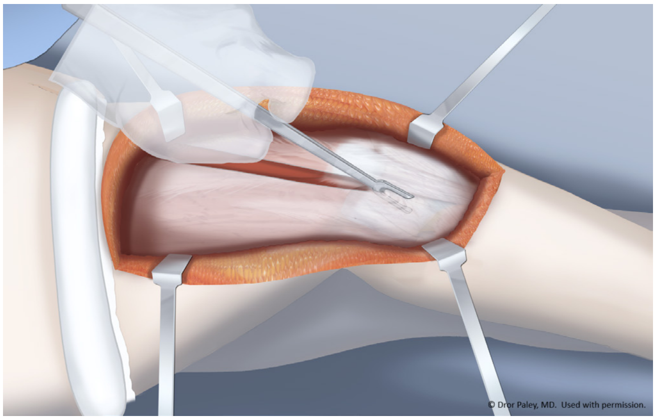

Fig. 2 A generous anterior incision is made under tourniquet control. The lateral and medial borders of the extensor mechanism are divided while staying extra-synovial. Figure printed with permission from the Paley Foundation.

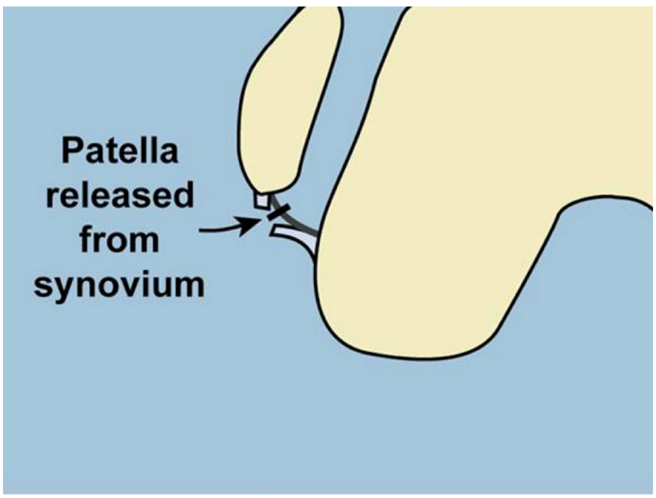

Fig. 3 A key step of the procedure involves elevating the retinaculum and musculature of the synovium. The synovium is a surprisingly strong, inelastic tissue that is crucial for maintaining the position of the patella. Figure printed with permission from the Paley Foundation.

is not entered until these layers are separated. In some cases, especially after previous operations the capsule and synovium can be difficult to separate and can be treated as a single layer medial and lateral to the patella. The layers are most easily differentiated under the patellar ligament and at the lateral aspect of the quadriceps tendon, making this an ideal location to begin the dissection. Once the retinaculum and musculature has been elevated off of the synovium (Fig. 3), the patella is now only adherent to the quadriceps tendon proximally, the patellar ligament distally and the synovium circumferentially. The synovium can then be circumferentially cut around the patella (leaving a synovial cuff for later repair). The entire intact extensor mechanism can now be lifted off the synovium (Fig. 4). The patella remains solely attached to the quadriceps tendon proximally and the patellar ligament distally. The synovium is now a free tissue layer with a patella-sized rent (Fig. 5). In cases of congenital patellar dislocation and congenital femoral deficiency, it is usually necessary to release the shortened biceps femoris and iliotibial band to overcome the lateral subluxation of the tibia (Fig. 6). The extensor mechanism is then retracted medially (Fig. 7a) and the hole securely closed in the synovium left by the patella in a longitudinal fashion with 0 Vicryl (Johnson & Johnson, Brunswick, New Jersey, USA) (Fig. 7b). At this point, the patella is extra-articular.

After the patella is separated from the synovium and the hole in the synovium is closed, the knee is placed in extension and a vertical line is drawn on the synovium at the location of the new desired position for the patella. An incision is made approximately 3 cm to 4 cm in length at this new medialized location on the synovium (Figs 8a and 8b). The patella should be provisionally secured to this perforation in the synovium with a suture on the superior medial aspect (Fig. 8c). The tourniquet can then be briefly deflated while flexing and extending the knee in order to accurately confirm proper patellar tracking. In the majority of cases, the Q angle is dramatically increased after the patella is relocated in a more medial position. When this is the case, a tibial tubercle realignment procedure should be performed (Fig. 9). We performed either a Grammont patellar ligament realignment[20] for skeletally immature patients or a Fulkerson tibial tubercle osteotomy and transfer[21] if skeletally mature. The Grammont procedure involves sharply elevating the patellar ligament insertion while keeping it confluent with the periosteum distally. The tendon is then medialized and secured with a robust absorbable suture. Proximal alignment of the quadriceps mechanism must be assessed and Judet quadricepsplasty[22] considered if the patella is not easily tracking prior to secure fixation. This is an extraperiosteal elevation of the quadriceps sometimes extending all the way up to the proximal femur. If there is patella alta especially in congenital cases, then femoral shortening osteotomy is considered which can resolve quadriceps tightness and help to resolve knee flexion contractures.

After confirmation of desired patellar alignment, circumferentially secure the patella to the synovium with a heavy running absorbable suture (Fig. 10). The medial side may be sewn tighter or looser to fine-tune the position of the patella. The lateral side is approximated without undue tension. Some might argue that the lateral side does not need to be repaired at all, however, we have no experience with that and feel that the patellar tilt is better controlled with a circumferential repair. Although the synovial layer is often thought of as a thin layer, it is actually quite robust and is a very effective stabilizer of the patella due to its lack of elasticity. Next, the Insall VMO advancement technique is used, similar to the technique Langenskiöld used in his original procedure.[8,9] This con-

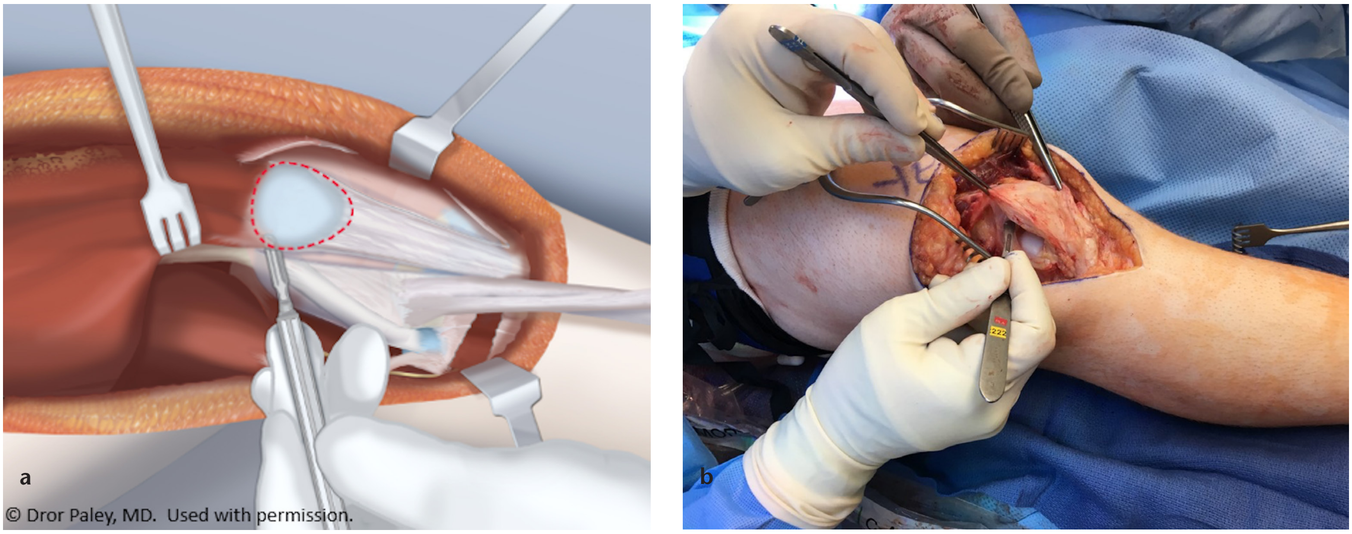

Fig. 4 a) The extensor mechanism (quadriceps tendon, patella, and patellar tendon) is elevated off the synovium while keeping the extensor mechanism intact; **b)** the extensor mechanism (quadriceps tendon, patella and patellar tendon) is elevated off the synovium while keeping the extensor mechanism intact. Figure 4a printed with permission from the Paley Foundation.

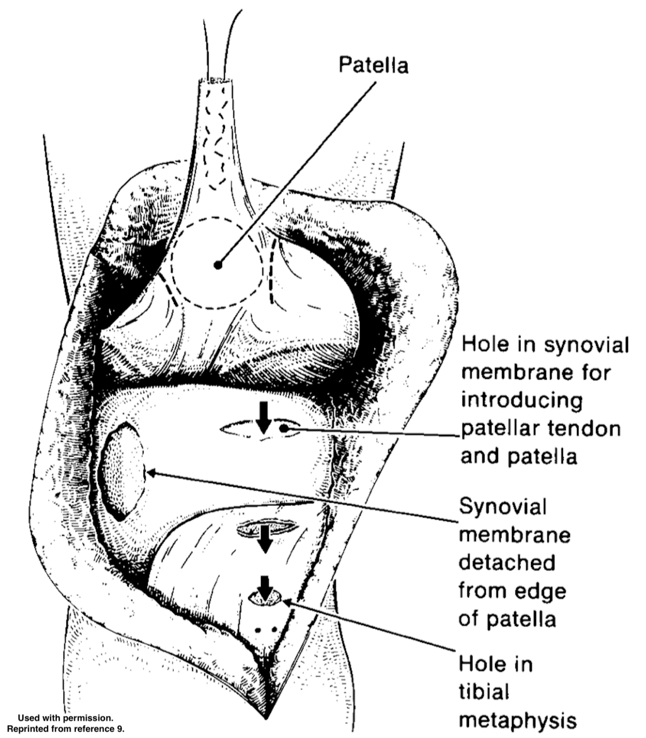

Fig. 5 This figure from Langenskiöld's original article shows the extra-articular position of the extensor mechanism after separation from the synovium. Our current procedure varies from the original in that we do not detach the distal insertion of the patellar tendon, which negates the need for the insertion hole in the tibial metaphysis (reproduced with permission from the authors).[9]

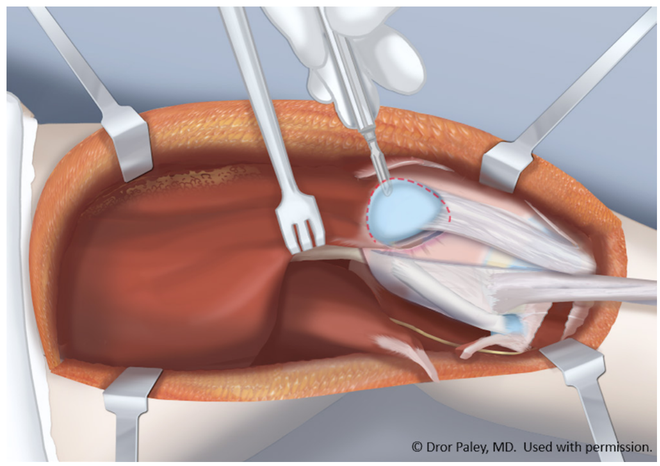

Fig. 6 In cases of congenital patellar dislocation and congenital femoral deficiency it is usually necessary to release the shortened biceps femoris and iliotibial band. Figure printed with permission from the Paley Foundation.

sists of elevating the medial retinacular flap and VMO and advancing them over the patella towards the inferolateral border. They are advanced at least to the patellar midline but most commonly all the way to the inferolateral border of the patella. The VMO medial retinacular flap can then be secured in place with several figure-of-eight sutures (Fig. 11). The lateral patellar retinaculum is not repaired. After releasing the tourniquet, gently take the knee through at least a 0° to 90° range of movement (ROM). The patella should track nicely without pulling out any sutures. Then, the remaining deep and superficial layers should be closed with absorbable sutures.

Postoperatively, patients are placed in a hinged knee brace locked in full extension and are allowed to bear weight as tolerated. Progressive ROM begins four weeks postoperatively with ROM to 0° to 45° and advanced to 0° to 90° at eight weeks. At three months postoperatively,

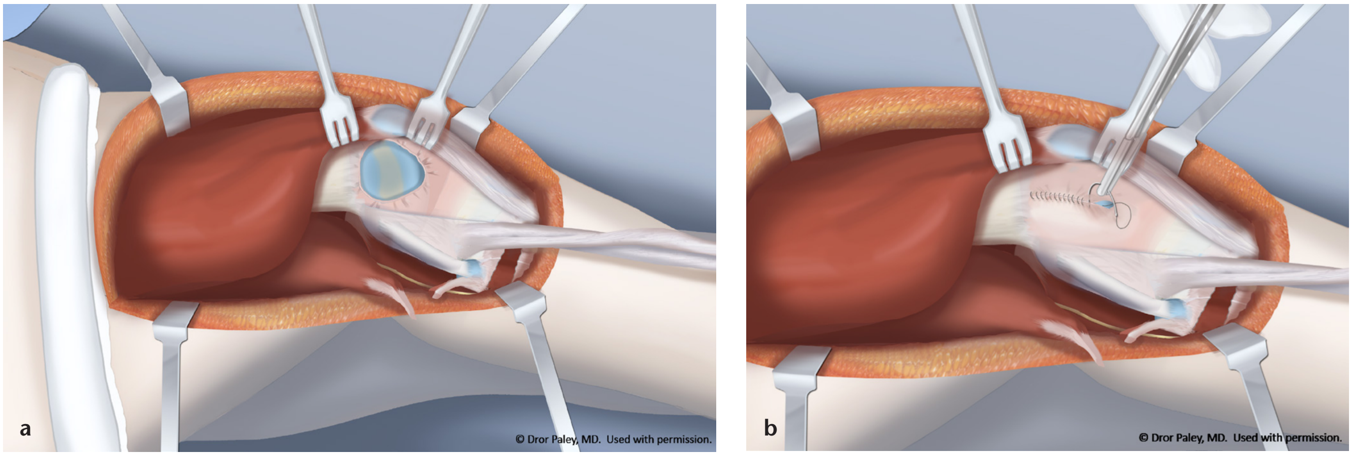

Fig. 7 **a)** The patella is completely detached from the synovium, leaving a central rent in the synovium; **b)** central rent in the synovium is closed with 0 Vicryl suture. Figure printed with permission from the Paley Foundation.

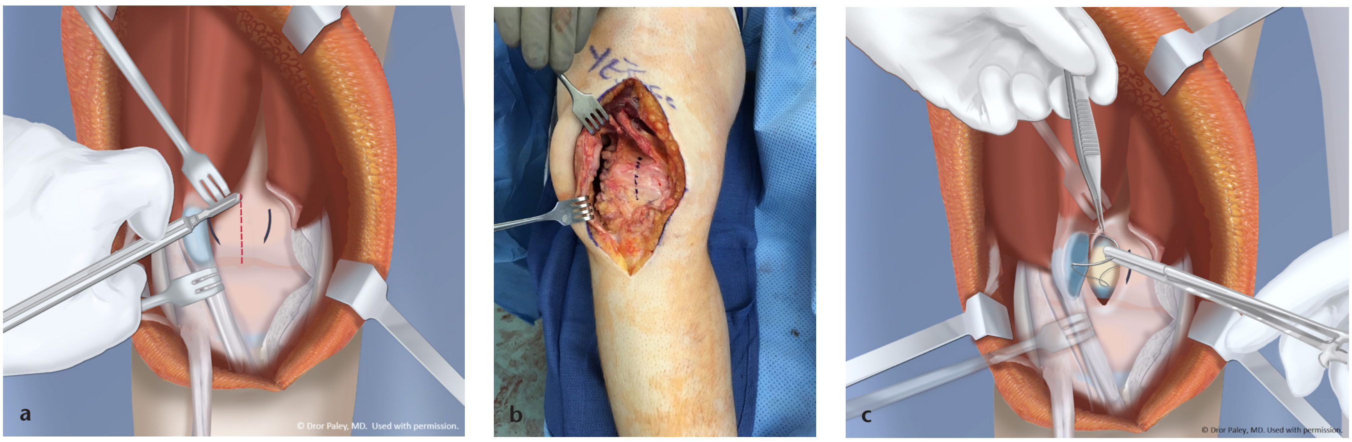

Fig. 8 **a)** The rent in the synovium left by the patella has been closed, and the intact extensor mechanism is lifted off the intact capsule and synovium. The entire extensor mechanism is now extra-articular. The patella is shifted medially to correct maltracking and the new desired locations of the medial and lateral borders are marked on the synovium (solid lines). A central line is marked (dotted lines) where a new synovial perforation is created to accommodate the patella; **b)** the rent in the synovium left by the patella has been closed, and the intact extensor mechanism is lifted off the intact capsule and synovium. The entire extensor mechanism is now extra-articular. The patella is shifted medially to correct maltracking, and the new desired locations of the medial and lateral borders are marked on the synovium (solid lines). A central line is marked (dotted lines) where a new synovial perforation is created to accommodate the patella; **c)** the patella is provisionally sutured to the superior aspect of this capsular perforation with one or two figure-of-eight sutures. The tourniquet is briefly deflated, and patellar tracking is tested through 0° to 90° knee range of movement. Figures 8a and 8c printed with permission from the Paley Foundation.

patients are allowed unrestricted ROM and may do physical therapy as needed.

Concomitant procedures

Although not every case requires every part of the modified Langenskiöld reconstruction, our Langenskiöld reconstruction technique consists of patella medialization within the synovium, distal patellar ligament realignment (Grammont or Fulkerson), proximal realignment as needed with VMO advancement, lateral release and in the case of congenital patella dislocation, release of biceps femoris and iliotibial band. Concomitant procedures were performed as indicated and included distal femoral varus osteotomies in six knees (five patients), proximal femoral derotational osteotomies in two knees (one patient) and one patient requiring posterolateral corner reconstruction, medial collateral ligament reconstruction and posterior capsule release in bilateral knees.

Results

In total, two out of 18 knees (11%) had further lateral dislocations after the modified Langenskiöld procedure. These occurred in one patient who had bilateral surgery

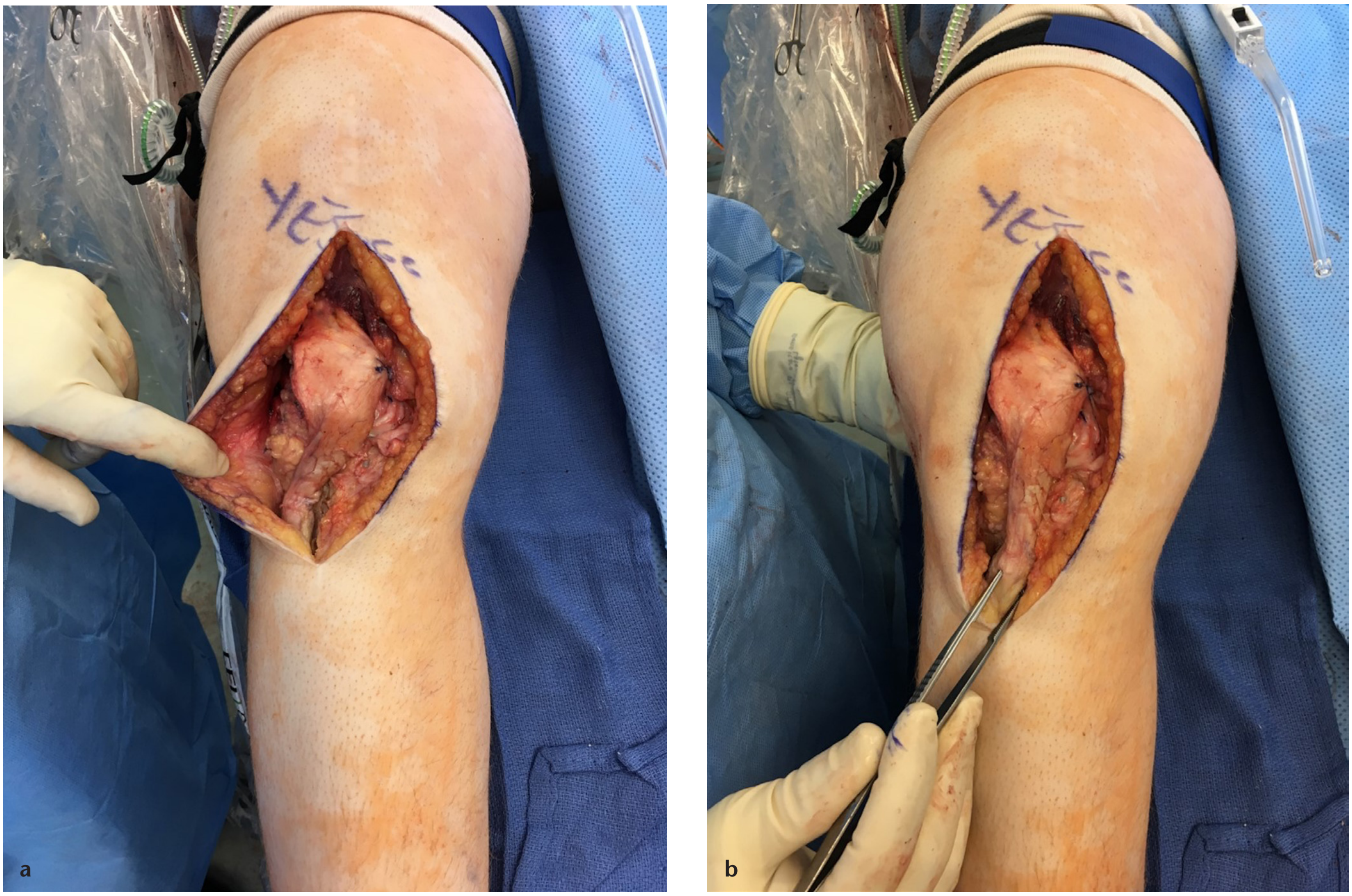

Fig. 9 a) In many cases, after relocating the patella the Q angle is dramatically increased; **b)** alignment of the extensor mechanism after a Fulkerson tibial tubercle osteotomy.

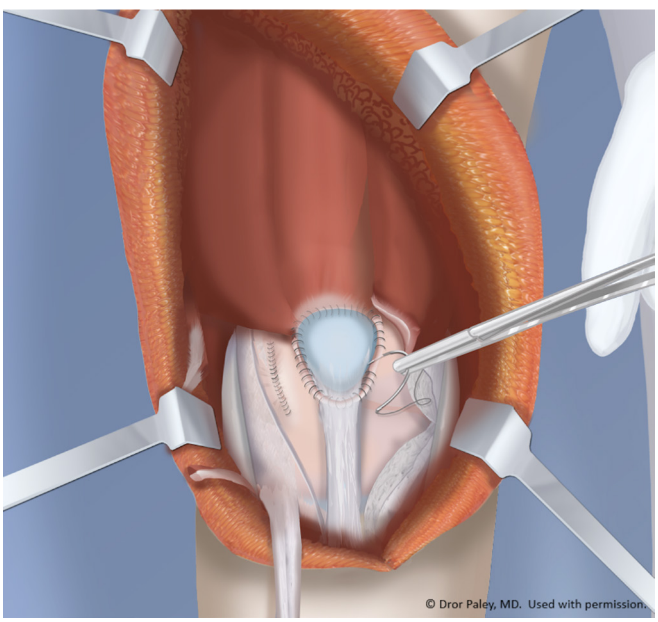

Fig. 10 Once the desired location is confirmed, the patella is sutured to the synovium with a circumferential running suture. Figure printed with permission from the Paley Foundation.

for chronic dislocations. They occurred intermittently and were first noted more than one year after the modified Langenskiöld. One patient with a congenital dislocation had an overcorrection with medial maltracking noted on follow-up. The remaining 15 knees in 11 patients did not have any further lateral dislocations with a mean follow-up of 4.7 years (SD 1.67; 2.0 to 9.4). Mean postoperative ROM was 1° (SD 10°) to 117° (SD 25°).

The mean Kujala score was 83.7 (SD 17;, 47 to 100), 75.8 (SD 21.2; 47 to 98) in the chronic dislocation group, 88.7 (SD 6.7; 81 to 93) in the congenital dislocation group and 86.5 (SD 18.1; 51 to 100) in the recurrent dislocation group (Table 2).

Patient-reported satisfaction was collected at latest follow-up for 11 patients. In the congenital dislocation group, two patients were very satisfied and one patient was satisfied with their outcome. In the chronic dislocation group, three patients answered the survey; two were very satisfied and one was very dissatisfied (patient with recurrent dislocations). In the recurrent dislocation group; five patients answered the survey, four were very satisfied and one was somewhat satisfied. One patient

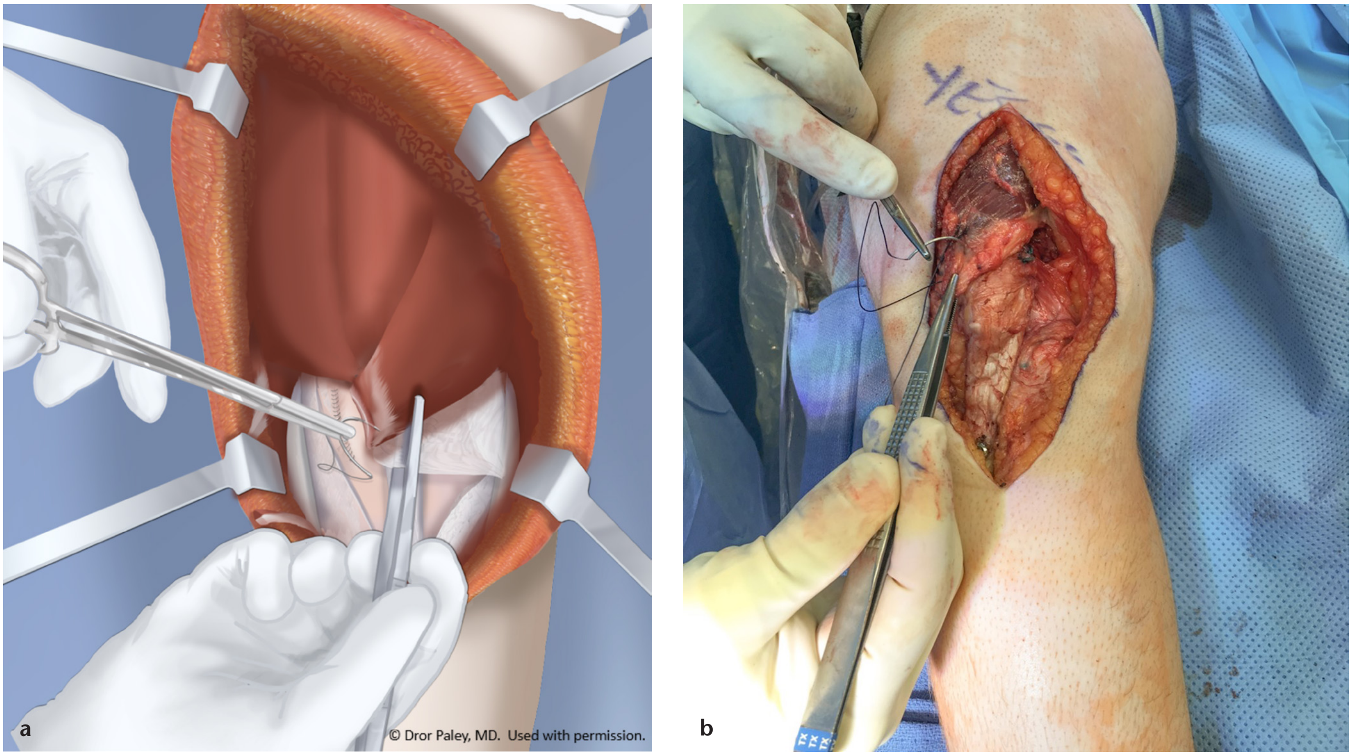

Fig. 11 a) The vastus medialis obliquus (VMO) is advanced over the top of the patella. Sometimes, it is advanced as far as the lateral aspect of the extensor mechanism, depending on the tension desired and on the muscle's elasticity; **b)** the VMO is advanced over the top of the patella. Sometimes, it is advanced as far as the lateral aspect of the extensor mechanism, depending on the tension desired and on the muscle's elasticity. Figure 11a printed with permission from the Paley Foundation.

Table 2 Results

ID	Re-dislocation	Kujala Score	Satisfaction	Pain	ROM (degrees)
Congenital dislocations					
1	No	92	Very satisfied	Slight/occasional	0 to 100 R; 0 to 130 L
2	No	93	Very satisfied	Slight/occasional	0 to 136
3	No	81	Satisfied	None	0 to 130
Chronic dislocations					
4	Yes (bilateral)	81	Very dissatisfied	Occasionally severe	0 to 120 R; 0 to 120 L
5	No	98	Very satisfied	None	0 to 150
6	No	77	Very satisfied	Slight/occasional	0 to 130
7	No	47	Unanswered	Occasionally severe	0 to 80
Recurrent dislocations					
8	No	86	Unanswered	Slight/occasional	0 to 130
9	No	100	Very satisfied	Slight/occasional	0 to 130 R; 0 to 130 L
10	No	94	Very satisfied	Slight/occasional	-10 to 150
11	No	51	Somewhat dissatisfied	Occasionally severe	0 to 140 R; 0 to 130 L
12	No	98	Very satisfied	Slight/occasional	0 to 130
13	No	90	Very satisfied	Slight/occasional	0 to 140 R; -5 to 140 L

ROM, range of movement

in the congenital dislocation group reported slight or occasional pain with activities and two patients reported no pain with activities. In the chronic dislocation group two patients reported occasional severe pain with activities, one reported slight or occasional pain with activities and one reported no pain with activities. In the recurrent dislocation group, five reported slight or occasional pain with activities and one reported occasionally severe pain with activities. At the time of most recent follow-up no patients had undergone any revision surgery for patella instability.

Discussion

In this study we detail the steps of the Paley modified Langenskiöld procedure and show evidence that this technique is valuable for treating challenging cases of congenital, chronic and recurrent dislocations. The modification by Dr. Paley involves leaving the patellar ligament extra-synovial as opposed to Langenskiöld's original description where it was placed inside the synovium and brought out of a second synovial perforation distal to the first. Their technique also differed from ours in that they detached the patellar ligament and reflected the patella proximally with its muscle. In our small series this procedure was especially successful in the recurrent dislocation group for which the technique has not been previously reported. In this subset of patients, we found no cases of further dislocation and the Kujala scores were consistently high. Our study also demonstrates that after this complex patellar realignment procedure knee pain can be a problem. In our series pain was reported in 10/13 patients (76.9%) and although slight or occasional in 53.8% of patients, it was reported as severe in 23%.

The latest follow-up knee radiographs of all the patients were reviewed. There was no significant varus or valgus noted, and the patella was centered and engaged on the trochlea. We did not see any signs of osteonecrosis including sclerosis, osseous collapse, fragmentation or joint effusion.[23-25]

Persistent knee pain after surgical relocation of the patella and improvement of its tracking in the trochlear groove can result from the degenerative chondral changes seen with multiple dislocations. It is well known that patellar dislocations are a significant risk for patellofemoral arthritis and even a first-time dislocation is associated with cartilage injury.[26,27] For patients with knee pain after a procedure that involves significant dissection about the patella, there is concern for devascularization and osteonecrosis of the patella. The patellar blood supply arises from the peripatellar vascular anastomotic ring, which is formed by five genicular arteries and the anterior tibial recurrent artery.[28-30] Previously, Lazaro et al[29] had reported that the largest arterial contribution to the patella entered through the distal patellar pole via the transverse infrapatellar branch. In the modified Langenskiold procedure, the only remaining soft tissues that remain connected to the patella are the quadriceps muscle minus the vastus medialis and the patellar ligament. We did not note any signs of osteonecrosis of the patella, presumably because the prepatellar vascular network entering through the quadriceps muscles and the distal pole of the patella are sufficient to maintain vascularity.

Langenskiöld and Ritsilä[9] described the novel reconstructive procedure for irreducible lateral congenital patellar dislocations. They reported satisfactory outcomes in 12 patients (18 knees) with no reported recurrent lateral dislocations after an average follow-up of > 13 years. In his personal unpublished series of more than 50 congenital dislocations Paley has also not had any recurrent lateral dislocations. He has noted several cases of medial maltracking due to the lack of a normal trochlear groove and the powerful correction that this technique provides. After addressing associated alignment issues there is a fine balance between over and under correction of patellar alignment due to a shallow, incongruent or in some cases non-existent trochlea. In spite of this, it still possible to balance the patellar alignment in most cases. The tendency for over correction was demonstrated in one of our congenital cases with postoperative medial maltracking.

The present study was undertaken to evaluate the outcomes of not only patients with congenital patellar dislocations, but also patients with chronic dislocations, and recurrent dislocations treated with the modified Langenskiöld procedure. We had a 33% lateral redislocation rate in the chronic patellar dislocation group which was represented by one bilateral patient in this small subgroup. This rate remains equal or lower than rates seen with other procedures.[5,6,31-34] This was a case of chronic previously operated bilaterally dislocated patellae which started experiencing recurrent lateral dislocations a year after our surgery. This complication could have been possibly avoided by further medialization of the patella. In Langenskiöld and Ritsilä's original paper,[9] they describe using a medial transfer of the patellar ligament in each case. Likewise, all but two patients in our study required patellar ligament realignment either with a Grammont patellar ligament realignment or Fulkerson tibial tubercle osteotomy and transfer. This is almost always necessary due to a markedly increased Q angle that is created after medializing the patella within the synovium. Medializing the patellar ligament creates a more medial vector force on the patella and decreases the Q angle. When planning a distal patellar realignment, it is important to assess for patella alta. This can be accomplished by using the Insall-Salvati[35] or Caton-Deschamps method.[36] The patella can be easily distalized during patellar ligament medialization if desired. If the quadriceps is excessively tight as often seen in congenital cases then this should be combined with a Judet quadricepsplasty.[22] In the current study, six knees were noted to have patella alta preoperatively and had distalization of the patellar ligament at the time of medialization. In congenital cases rotatory subluxation of the tibia and flexion contracture can also be an issue and may need to have a SUPERknee reconstruction including a reverse MacIntosh extra-physeal anterior cruciate ligament reconstruction combined with biceps femoris release and peroneal nerve decompression.[37]

Conditions that need to be assessed during preoperative physical exam and imaging include knee ROM, femoral anteversion, external tibial torsion, ligamentous laxity, genu valgum, patella alta, trochlear dysplasia and increased tibial-tuberosity to trochlear grove (TT-TG) distance.[19,38] In addition to the standard patellar instability examination, physical exam must include a rotational profile to assess for femoral anteversion or external tibial torsion. We consider rotational osteotomies for femoral anteversion > 25° to 30° from normal.[39,40] External tibial torsion should be assessed by measuring the transmalleolar axis, thigh foot angle and observing gait. If excessive external tibial torsion in addition to increased femoral anteversion is present ('miserable malalignment') a derotational tibial osteotomy should be considered in addition to femoral osteotomy.[41] It is important to note that the rotational and angular alignment of the lower extremity in children changes with age and the surgeon should be aware of the values typical for a particular age.[42,43]

We perform a comprehensive limb deformity analysis with full length lower extremity images for all patients prior to indicating operative treatment for patellar instability. It is important to assess mechanical axis deviation (MAD) (normal axis 0 mm to 10 mm medial to centre of knee), lateral distal femoral angle (LDFA) (normal 88°) and medial proximal tibial angle (MPTA) (normal 87°).[44] Genu valgum leads to a lateral vector force on the patella and can contribute to instability. Correction of genu valgum is imperative for the success of any patella stabilization procedure. This is often done in the distal femur but depending on the LDFA and MPTA it may be performed in the proximal tibia or both. The goal is to have a matching LDFA and MPTA approximating 90° with a MAD of 0 m. Distal femur varus osteotomies were performed in patients with MAD lateral to the centre of the knee and LDFA < 85°. Joint line convergence issues (excessive medial collateral ligament (MCL) or lateral collateral ligament (LCL) laxity) must also be taken into consideration as they can cause malalignment even with normal LDFA and MPTA. It is preferable that the LDFA/MPTA are in the 85° to 90° range.[44-46] If matching MPTA and LDFA angles are < 85° there is concern about joint line obliquity causing lateral tibial subluxation. This direction of joint line obliquity is known as the 'bad pattern' whereas obliquity in the opposite direction (LDFA and MPTA > 90°) would be protective against lateral tibial subluxation. Mild joint obliquity in this direction is considered the 'good pattern' and is tolerable in the 90° to 95° MPTA/LDFA range.[44] Intraoperatively, after appropriate limb alignment has been obtained, patellar stability is assessed by taking the knee through full ROM before proceeding with the Langenskiöld.

The modified Langenskiöld procedure offers an alternative to other forms of patellar realignment for severe or recalcitrant cases of patellar instability. The technique of removing the patella from the synovium and re-introducing it in a medialized position allows for improved patellofemoral tracking, which is appreciated intraoperatively. The synovium is remarkably strong and more inelastic than one may imagine and contributes significantly to the success of the procedure. In this series, the Langenskiöld procedure produced considerable improvement in function and resolved patellar instability in cases of recurrent, chronic and congenital patellar dislocations. Indications for the Langenskiöld procedure were chronic patellar dislocations, congenital patellar dislocations and recurrent patellar dislocations associated with lateral patellar maltracking and trochlear dysplasia, or, recurrent dislocations associated with genu valgum needing surgical correction. In patients with recurrent patellar dislocations and trochlear dysplasia, MPFL reconstruction has a high risk of failure.[47,48] For patients with associated pathology such as genu valgum, femoral anteversion or patella alta, the Langenskiöld technique can be successfully implemented in combination with the indicated deformity correction procedures. No matter what method of soft-tissue stabilization is used, it is very important that bony alignment is addressed, otherwise failure is likely. For patients with generalized ligamentous laxity or trochlear dysplasia, the modified Langenskiöld provides a robust stability but it should not be used as a substitute for limb realignment.

This study has some limitations. This is a heterogenous group of patients with multiple comorbidities who underwent multifaceted reconstructive procedures for patellar instability. Although these may be representative of the refractory types of cases that are referred to a tertiary centre, it does make it difficult to attribute all of the success of the procedure to the Langenskiöld soft-tissue component of the technique. In this series limb malalignment was addressed with concomitant procedures. Our patients still had multiple comorbidities including issues of trochlear dysplasia and soft-tissue laxity for which the Langenskiöld soft-tissue reconstruction demonstrated success. These cases would not likely have resolved with standard types of patellar stabilizing procedures. We would consider it irresponsible to perform an isolated soft-tissue procedure while ignoring limb malalignment and thus it was necessary to combine this procedure with limb realignment in many of our cases. We do not have a control group and our series is not large especially when considering the subgroups. A single-centre study allows a more precise assessment of a surgical technique as it avoids the heterogenicity seen in large multicentre studies in which many different surgeons are involved. Additionally, our 4.3-year average follow-up is relatively short when compared with similar studies evaluating surgical techniques to treat complex cases of patellar instability.[3,5] We attempted to re-evaluate all the patients in an outpatient clinic, however, some patients had moved out of state and were only available by telephone. Four patients did not have current contact information and we were unable to reach them.

Conclusion

The modified Langenskiöld reconstruction provides a powerful correction for challenging cases of congenital and recurrent patellar dislocation. Re-dislocation as well as overcorrection can occasionally occur.

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COMPLIANCE WITH ETHICAL STANDARDS

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ETHICAL STATEMENT

Ethical approval: Institutional review board approval was obtained for this study. All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.
Informed consent: Was obtained from all individual participants included in the study.

ICMJE CONFLICT OF INTEREST STATEMENT

SN is an educational consultant for NuVasive, OrthoSpine, and Orthofix, outside the submitted work.
MM is an educational consultant for DePuy Synthes Spine and OrthoPediatrics, and also reports grants from POSNA for work not related to this study.
DP has stocks or stock options in Devise Ortho and Orthex, serves as a consultant for Nuvasive, and receives royalties from Orthopediatrics, Peega Medical, Smith and Nephew, and publishing royalties from Springer.
The other authors report no conflict of interest.

AUTHOR CONTRIBUTIONS

OR: Performed the data collection, Wrote the original draft, Assisted with the revisions.
CB: Performed the data collection, Wrote the original draft, Assisted with the revisions.
ML: Performed the data collection, Wrote the original draft, Assisted with the revisions.
MM: Contributed to the conceptualization of the study, Critical review of original manuscript, Revision of original manuscript.
DP: Contributed to the conceptualization of the study, Critical review of original manuscript, Revision of original manuscript.
SN: Contributed to the conceptualization of the study, Critical review of original manuscript, Revision of original manuscript.

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