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Modern Treatment of Recurrent Patellofemoral Instability – Combined Medial Patellofemoral Ligament Reconstruction and Tibial Tubercle Transfer

Moderní léčení recidivující patelofemorální instability – rekonstrukce mediálního patelofemorálního ligamenta a transpozice *tuberositas tibiae*

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ABSTRACT

PURPOSE OF THE STUDY

The treatment of recurrent patellofemoral instability has undergone a paradigm change during the last 15 years. Instead of non-anatomical operations, the current concept favors the reconstruction of injured structures and the normalization of the biomechanical environment. Our aim was to briefly summarize the etiology, diagnostic regimen, and therapeutic decision making of this varied patient group and to review our own patients who underwent combined medial patellofemoral ligament reconstrucion and tibial tubercle transfer.

MATERIAL AND METHODS

Between 2015–2017 we performed combined ligament reconstruction and tubercle transfer for recurrent patellofemoral instability on 10 patients. The patients were examined for the degree of trochlea dysplasia, height of the patella, tibial tubercle trochlear groove distance. Additional intraarticular abnormalities were noted. The patients were assessed preoperatively and at follow-up using the Tegner Activity Scale and the Kujala score. Return to sports was also examined.

RESULTS

The average age of our patients was 22 years (15–40). We had 6 female patients and 4 male patient. The average follow-up time was 29 months (12–44). 9 patients had a medializing of the tibial tubercle, whilst one patient had a pure distalization to go along with the medial patellofemoral ligament reconstruction using PEEK tenodesis screws. We had no redislocations up to the last follow-up and patients were able to return to their previous activity level and/or sporting activity. The Kujala score improved from an average preoperative value of 48.9 (32–58) to an average follow-up value of 88.6 (70–97).

DISCUSSION

The essential steps in the treatment of recurrent patellofemoral instability are a thorough physical examination, appropriate imaging and the individual correction of the uncovered anatomical abnormalities. Neither isolated lateral retinacular release, nor medial capsular reefing can preictably produce satisfactory results.

CONCLUSIONS

Medial patellofemoral ligament reconstruction with tibial tubercle transfer (medializing and/or distalization) is a reliable surgical technique, that provides long term patellar stabilty in this selected group of young patients.

Key words: patellar dislocation, joint instability, ligaments, tendon transfer.

INTRODUCTION

The term patellofemoral instability represents a spectrum of disease, starting with patellar subluxation and ending with a permanently dislocated kneecap. Neither the definition, nor the terminology are crystal clear. Sometimes, the description relates to a symptom, such as pain, when the patella leaves the trochlea, other times it describes a physical examination finding, such as being able to lateralize a mobile patella in a certain flexion position (2). Amongst the most common presentations, we can differentiate, first, usually traumatic dislocation; recurring dislocation and habitual patellofemoral instability, when every flexion will be accompanied by lateral displacement of the kneecap. Patellofemoral instability is not only associated with pain, but decreases the ability to be able to carry out sporting activity and can lead to premature degenerative changes in the anterior part of the knee (20).

This paper describes the current principles of surgical treatment of recurring patellar dislocation, and summarizes our experiences with combined medial patellofemoral ligament (MPFL) reconstruction and tibial tubercle transfer, through reporting our own cases and results.

Etiology

Patellofemoral instability affects adolescents and young adults, with no significant differences between the genders. The first dislocation usually occurs during sporting activity or dancing (70%) (7). The growth plates are open in one third of the patients, who suffer a first dislocation, whilst the other two thirds have a mature skeleton (15). Conservative therapy can be successful in 70% of patients, whilst 30% will go on to have recurrent instability, half of which will eventually require surgical intervention (16). Undergoing conservative treatment only, does not necessarily mean that the patient remains asymptomatic.

Predisposing factors

The dynamic relationship between the patella and trochlea during flexion, is provided by the static stabilizers (the bony congruence and ligamentous restraints of the patellofemoral joint) and the dynamic stabilizers (the muscles affecting knee movement).

The most frequent anatomical variant that can be found in patellofemoral instability patients is a high-riding patella, or patella alta. The kneecap is higher than usual, which results in that the patella engages the trochlear groove at a later point. The height of the patella is best measured on a lateral radiograph. A frequently used method to characterize patellar height is the Insall-Salvati ratio (11), which calculates a ratio between patella length and the length of the patella tendon (Fig. 1.).

A dysplastic trochlea, means that the sulcus angle of the trochlea is higher than normal (> 145 degrees), i.e. the trochlear groove is shallower. This is the most frequent risk factor for recurrent patellar dislocation (Fig. 2.). The depth of the trochlear groove is less than the usual value (< 3 mm). The classification of trochlea dysplasia is performed according to the Dejour classification (4).

The quadriceps angle or Q-angle is increased in patients with patellofemoral instability. The anatomical axis of the lower limb/knee often exhibits a valgus alignment.

There are also some lower limb torsional anomalies (an outwardly rotated tibial tubercle, or an inversely internally rotated distal femur), however these changes show great variance, thus it is difficult to draw definite conlusions, whether there is a causative relationship between them, and dislocation of the kneecap.

General hyperlaxity is often mentioned as a potential risk factor for instability, but definitive conclusions on current evidence cannot be drawn.

The most frequent combination of risk factors is patella alta with trochlear dysplasia. If the first dislocation occurs before the age of 25, and the patient has a high riding patella, there is a 34% chance that the patient will have another dislocation within 5 years. If in addition

Fig. 1. Lateral radiograph of the knee, showing slight patella alta. The Insall-Salvati ratio is 1.28.

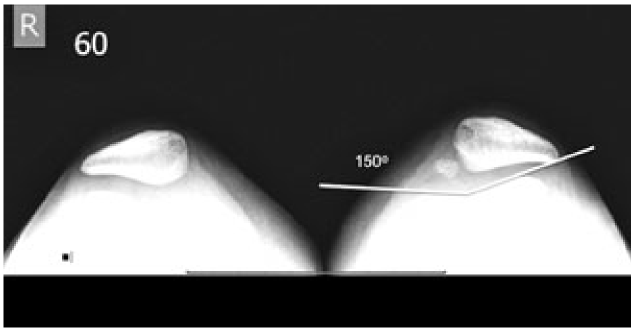

Fig. 2. The skyline view of the patella shows a small bony avulsion on the medial side of the patella. The sulcus angle on the left is 150 degrees.

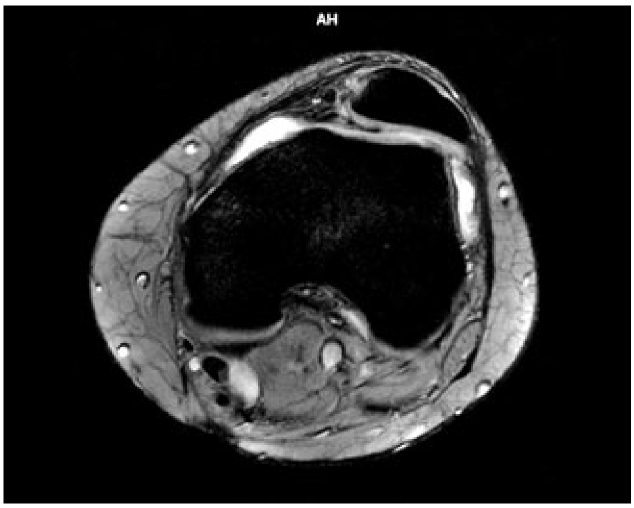

Fig. 3. Axial T2 MRI slice of the left knee. Dejour type B trochlea dysplasia. The sulcus angle is increased, the trochlea is convex, the patella is lateralized, and there is early degenerative changes on the lateral edge of the trochlea.

the patient also has trochlear dysplasia, this risk rises to 70% (15).

Diagnosis

After a detailed patient history (specific circumstances of the dislocation), a throrough physical examination should be able to describe, lower limb alignment, the Q-angle, approximate patellar height, patellar mobility/hypermobility. The quadrant method described by Kolowich (13), is an useful tool, and virtually divides the knee on an axial slice into four equal parts – quadrants. 2 or more quadrants of displacement laterally represents a hypermobile patella. The dynamic apprehension test performed in the awake patient, correlates well with the preoperative examination performed under anaesthetic, with a sensitivity of 100% and a specifity of 88% (1). During the test, we perform knee flexion to 90 degrees, whilst we use our thumb to push the patella laterally. We repeat the same examination, but use our index finger to push the patella medially. We observe the patient's reaction and muscle contractions/muscle protection. The test is positive if the patient requests to stop the examination, or the patient contracts the quadriceps as a means of protecting the kneecap from subluxation/dislocation.

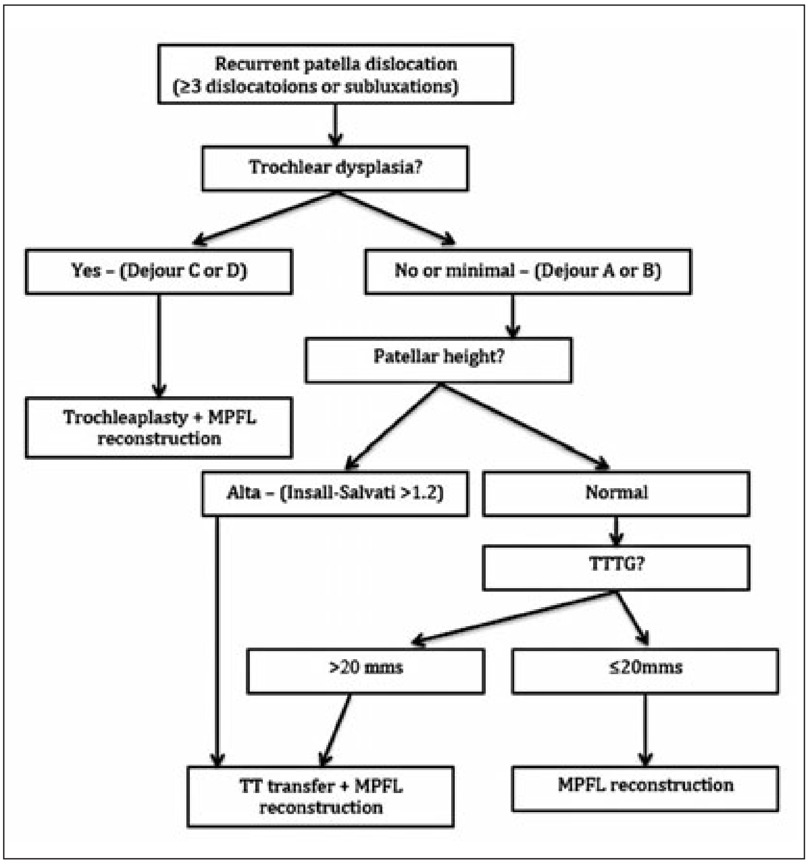

Fig. 4. Treatment algorithm for recurrent patella dislocation.

Plain radiographs are essential, and should be requested in all cases. Both knees should have and anteroposterior (AP) lateral and a skyline view. Based on these, the patellar height and the degree of trochlea dysplasia can be determined (Fig. 1 and Fig. 2). On long leg views, the mechanical and anatomical axis can be measured. The radiographs can also show osteochondral fragments. An MRI scan is mandatory for surgical planning. In the acute setting, injury to the MPFL is well visualized, along with any potential concomittant injuries, such as lateral femoral condyle bruising, chondral or osteochondral injury to the trochlea and/or patella. Superposing axial T2 weighted MR images on each other, allows the measurement of the distance between the deepest point of the trochlear groove and the middle of the tibial tuberosity. This measurement yields the tibial tuberosity trochlear groove distance, with a normal value of 10±1 mm (for patients without patellofemoral problems) (19). A value of more than 20mm, almost always carries the risk of patellofemoral instability. MRI also helps to detail the morphology of the trochlea and the radiological parameters are easy to define, such as the inclination of the lateral trochlea (less than 11 degrees means dysplasia), asymmetry of the trochlear facets (if the medial is less than 40 % of the lateral – means dysplasia), sulcus angle (the angle between the medial and the lateral facet – over 150 degrees is abnormal), trochlear depth (less than 3mm means dysplasia).

Treatment

A first patella dislocation can be treated conservatively except if there is an osteochondral fragment within the joint, or if there is evidence of other chondral injury, which requires surgical treatment (usually meaning knee arthroscopy). The cornerstone of conservative treatment is, initial immobilization and non-weight bearing, supplemented by symptomatic treatment (local cooling and pain relief medication). Once the swelling improves, this is followed by strengthening of the vastus medialis, stretching the iliotibial band, using a brace or taping the knee and avoiding any provoking sports or other recreational activity.

Surgical treatment

In the case of recurrent patella instability the surgical algorithm can be formulated on the basis of the patient's history, physical examination, radiographs and MRI. The cornerstones of successful surgical treatment are correction of anatomical anomalies, predisposing factors and reconstruction of structures that were injured during the dislocations (Fig. 4). An MPFL reconstruction is always required, and is performed using a hamstring autograft. Bony deformities have two main groups.

A. In the case of the relatively rare severe trochlea dysplasia (Dejour type C or D), a trochleoplasty might be required, when the flat or convex trochlea is corrected. There are several techniques to do this, the most popular is the sulcus deepening trochleaplasty, when a trough is created subchondrally by removing some cancellous bone from underneath the trochlear subchondral bone and fixing the trochlea in the new position (18).

B. If there is an increased TTTG distance, then medialization and/or distalization of the tibial tubercle is in order.

Combining these bony procedures is also a possibility for complex deformities. In our case series we descibe the combined tibial tubercle transfer and MPFL reconstruction.

MATERIAL AND METHODS

Between 2015–2017 we performed 10 combined tibial tubercle transfers and MPFL reconstructions.

Surgical technique

During the operation the patient is positioned supine, with a side support, and a pillow which keeps the knee in roughly 20–30 degrees of flexion. Tourniquet is used without exsanguination. If on the basis of the MRI, there is a need to remove, refix an osteochondral fragment, we start with a routine knee arthroscopy. An additional superolateral portal should be used to assess patellar tracking before and after surgery.

The next step is performing the tibial tubercle transfer for medialization and/or distalization. Correction is performed according the preoperative plan (measured in millimeters). The aim of medailization is to bring the TTTG distance into the normal range, whilst distalization lowers the patella, to provide a normal patellar height. The tibial tubercle osteotomy is performed according to the technique descibed by Fulkerson (8), creating a long (6–8 cm) distally tapered osteotomy. If there is no distalization required, the distal soft tissue attachments can be left intact for quicker healing (Fig. 5). Anterior displacement/elevation is not routinely performed. The osteotomy is fixed with two fully threaded 4.5 mm AO cortical screws, used in a bicortical lag screw fashion, with compression. The position of the osteotomy and the screws is checked intraoperatively with an image intensifier (Fig. 6).

Next, the required gracilis tendon is harvested by using a small oblique anteromedial incision, or a transverse one in the popliteal fossa (depending on the prefered harvest technique of the operating surgeon). The preparation (debridement and whipstiching) of the hamstring is performed, in a similar fashion to what is used in ACL reconstruction. The medial side of the kneecap is exposed, and two guide wires are drilled into the kneecap, paralell to each other. Their position is checked both in the AP and lateral plane, and the wires are drilled through the patella, all the way. The wires are overdrilled to the depth of 15 mm by using a cannulated drill (4 or 5 mm in diameter), to create two patellar sockets for the screws used to fix the tendon ends (PEEK tenodesis screws, Sanatmetal®, Eger, Hungary). The two ends of

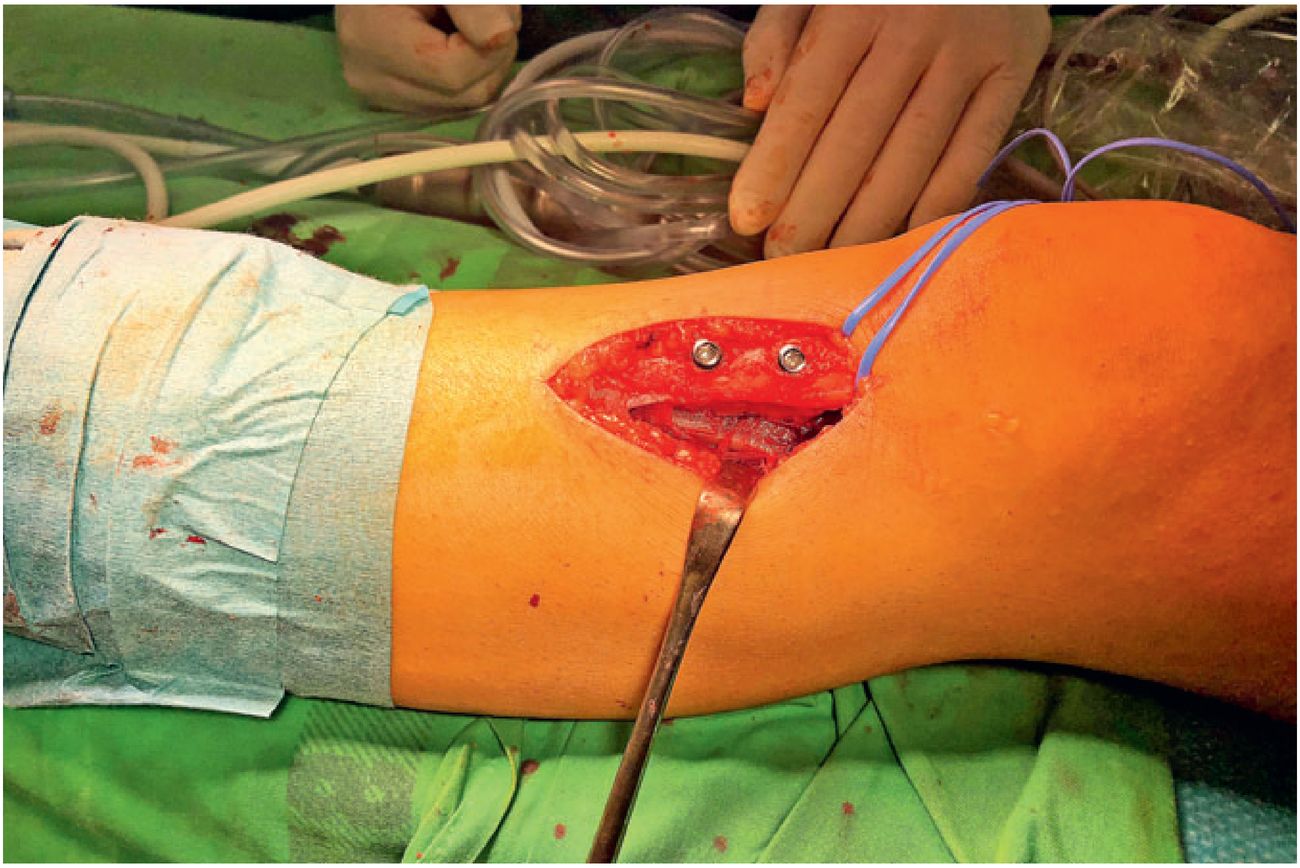

Fig. 5. Fulkerson osteotomy performed first. Medialization of 8 mm have been performed. A rubber band is protecting the patella tendon. There was no need for distalization.

Fig. 6. Intraoperative lateral image intensifier view of the knee showing the two large fragment AO screws used to fix and compress the osteotomy.

the prepared graft are pulled into the sockets and fixed (Fig. 7). Before preparing the femoral tunnel, a subcutaneous, extracapsular tunnel is bluntly prepared on the medial side between the medial vastus attachment and the joint capsule. The entry point of the femoral tunnel is marked by using the image intensifier, in the isometric point, somewhat proximal and dorsal to the medial femoral epicondyle. A transparent aiming decive can be used for this step. After the graft has been pulled into the tunnel the knee is positioned in the 30 degree flexed position to allow adjustment of the tension of the reconstructed MPFL. Overtightening should be avoided. For the femoral fixation we also use a PEEK tenodesis screw (usually 6 mm in diameter). We check patella tracking throughout the range of flexion. After releasing the tourniquet, haemostasis is attained, and the wound closure is performed in the routine fashion.

The postoperative rehabilitation starts on the first postoperative day. Postoperative check radiographs are performed (8a and 8b). Continuous passive movement (CPM) is initiated, and the patients are mobilized in a brace with touch toe weight-bearing. The first two weeks are spent with an allowed range of movement (ROM) of 0–30 degrees. ROM is increased to 0–60 for a furhter two weeks, and 0–90 from weeks four to six. At the six-week follow-up a radiograph is performed, and gradual weight bearing is allowed. Sporting activity is not allowed for the first six months.

Fig. 7. The distal limb of the gracilis graft is fixed in the patella by using a PEEK tenodesis screws.

Scoring systems for evaluating the surgical results

Assessment of the patellofemoral function was performed using the Kujala score (14), which consists of 13 questions and is used and validated for anterior knee pain and patellofemoral disorders. This score grades the function from 0–100.

Physical activity and sports were measured using the Tegner activity scale (22), which is a scale from 0-10, where 0 means long term disability or handicap due to knee problems, and 10 means national elite level sporting activity.

RESULTS

All of the surgical procedures were performed by the first and last authors. 9 patients had a Fulkerson type osteotomy whilst one had a mainly distalizing osteotomy, due to a high riding patella.

The average age of patients was 22 years (15–40). We had 6 female and 4 male patients. By grading trochlea dysplasia, we found that 6 pateints had Dejour type A (increased sulcus angle) and 4 had Dejour type B dysplasia (flat trochlea).

The TTTG distance was above 20 mm in 9 cases, whilst one patient had a relatively normal value (40-year-old female patient – 13 mm).

The patella height was extremely high in one case (Insall-Salvati 1.5), whilst the other patients had values, on the upper end of the normal range (from 1.15 to 1.28).

Minimum follow-up time was 1 year. We had no intraoperative or early postoperative complications. A 15-year-old female patient slipped in the bathroom on the 5th postoperative week, and fell onto the operated kneecap, suffering a transverse nondisplaced patella fracture, which was treated conservatively in the brace, and healed uneventfully. None of the patients had further episodes of subluxation or dislocation.

Fig. 8. AP (a) and lateral (b) postoperative radiographs of the knee (performed in a brace). Both the screws of the osteotomy and the three PEEK tenodesis screws fixing the MPFL reconstruction are visible.

Detailed patient data and functional outcome is outlined in Table 1. All patients were satisfied with the overall results and would be happy to undergo surgical treatment agian.

DISCUSSION

Detailed understanding of the biomechanics of the patellofemoral joint and the pathology of recurrent patellofemoral dislocation has brought a paradigm change in the surgical treatment of this patient group. The old principles, that to treat the instability of a joint,

Table 1. Patient data and functional results

	Age (at surgery)	Gender	Side	Follow-up (months)	Tegner preop.	Tegner control	Kujala preop.	Kujala control
Patient 1	15	female	left	44	7	7	44	87
Patient 2	15	female	left	40	7	7	47	92
Patient 3	40	female	right	31	4	4	48	82
Patient 4	17	male	left	18	1	5	58	96
Patient 5	15	female	left	12	2	4	32	80
Patient 6	37	male	right	14	5	5	57	93
Patient 7	15	female	right	21	1	3	41	70
Patient 8	24	male	right	27	5	5	46	97
Patient 9	25	female	left	17	4	4	58	94
Patient 10	17	male	right	18	6	6	58	95

one should introduce an extraarticular restraint that reduces range of movement has been disproved, and anatomical reconstruction of the affected structures has become the default technique for treatment.

For decades, lateral retinacular release was the corner stone in the treatment of patellar dislocation both as a standalone procedure, and in conjunction with a medial imbrication/soft tissue tightening operation. The ideological background of this surgical procedure, perhaps includes the idea that an overly tight lateral retinaculum is at least partially a predisposing factor in patellofemoral instability. Although arthroscopic retinacular release is an established procedure in the treatment of patellofemoral hyperpression/patellar chondromalatia, in the treatment of recurrent patellofemoral instability it is not recommended either as a standalone procedure (13), nor in combination with medial reefing (12), moreover, if it is used as an auxillary procedure to MPFL reconstruction, the results are inferior to MPFL alone. Malatray et al. performed a randomized study to compare the results of MPFL reconstruction with and without lateral retinacular release, and came to the conclusion, that there is no benefit of releasing the lateral retinaculum (17).

Historically, procedures involving the medial side of the patella included, reefing/doubling/tightening of the medial capsule and vastus medialis to act as a reinforced restraint against lateral translation of the patella and aimed to reconstruct injured medial structures. The applied techniques use drillholes through the patella or reattach the ruptured soft tissues to the medial capsule. This was potentially supplemented by the distalizing of the vastus medialis. The applied techniques and fixation methods were not standardized, and the created medial restrained was never isometric. The detailed anatomy of the medial stabilizers of the kneecap have been known for more than 40 years (23). The thorough understanding of the function and biomechanics of the MPFL have aided the development of reconstruction options (21). The MPFL is the main stabilizing force during the first 30 degrees of flexion, and is solely responsible for 60% of counter forces against the lateralizing vector (5).

During a patella dislocation the chances of a MPFL rupture is 95–100%. The injury to the ligament most frequently takes place at the femoral origin, or near to it. Reconstructing the MPFL alone, restores the medial stabilizing force on the patella. Further medial imbrication does not improve this any further (10), thus it seems logical that reconstructing the MPFL is the most important surgical procedure for balanced patellar tracking and stability.

The Q-angle or quadriceps vector is a 55-year-old concept (3), and describes the angle between the lines connecting the anterior iliac spine and the patella, and the patella and the tibial tuberosity. Decreasing the Q-angle (by medializing the tuberosity) has been an essential part of the surgical treatment of patellofemoral instabilty (if the Q-angle falls outside of the normal range). Biomechanical studies do not necessarily support decreasing the Q-angle, as by medailising the tibial tuberosity, medial patellar contact pressures increase, which might lead to early degenerative change. Furthermore, the biggest problem is, that determining Q-angle is subjective, its normal range is debatable. The Q-angle is a dynamic parameter, as it decreases during flexion. The other often used parameter is the TTTG. Measuring the TTTG was first described on plain radiographs more than 40 years ago (9). They measured the distance between the middle of the tuberosity and the deepest point of the trochlear groove in 30 degrees of flexion. Current cross sectional imaging methods allow accurate, objective and reproducible measurement of the TTTG distance which correlates well with the Q-angle (6). The required correction can be accurately planned.

CONCLUSIONS

In summary, the essential steps in the treatment of recurrent patellofemoral instability are a thorough physical examination, appropriate imaging (MRI) and the individual correction of the uncovered anatomical abnormalities. Neither isolated lateral retinacular release, nor medial capsular reefing can preictably produce satisfactory results. Combined MPFL reconstruction and tibial tubercle transfer (medializing and/or distalization) is a reliable surgical technique for a selected patient group and provides long term patellofemoral stability in this young, difficult to treat patient population.

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