48 Basic Concepts in the Diagnosis and Treatment of Patella Instability and Dislocation

Jinzhong Zhao and Hui Zhang

Patellar dislocation can occur in patients with perfectly normal patellar alignment due to direct trauma. It may also occur in patients with abnormal alignment of the patella, especially in patients with preexisting subluxation of the patella. In patients with subluxation of patella, patella dislocation is more likely to occur with or without patella tilt. Patellar dislocation may also occur after total knee replacement. Acute cartilage injuries are common, whether due to direct violence to the patella or due to the strong contraction of the quadriceps.

The Causes of Patella Dislocation

In normal conditions, the patella tends to shift laterally. From the static aspect, this tendency is passively counteracted by the pulling of the medial patellofemoral ligament (MPFL) and the obstruction of the lateral femoral condyle. On the dynamic side, the tendency of lateral dislocation of the patella is limited by contraction of the vastus medialis muscle. This balance is broken when acute or recurrent patella dislocations occur. In some cases, a force imbalance in the extensor device may be a major factor in patella dislocation. However, in most cases, patella dislocation is associated with abnormal bone morphology.

Many authors have pointed out that patellar dislocation has a familial tendency. Bowker et al. reported a family history in 25% of the 48 patients they studied [1]. Crosby et al. found that 28% had family history [2]. Patients with Down syndrome are prone to patellar dislocation, and there may be an association between Turner syndrome and recurrent patellar dislocation. Recurrent patellar dislocation also occurs with Kabuki make-up syndrome.

Skeletal Abnormalities

Trochlea Groove Abnormality There are two possibilities of trochlear groove abnormality. One is dysplasia of the lateral femoral condyle without elevation of the bottom of the trochlea groove, that is, the lateral femoral condyle is too low to lose the obstruction to the lateral displacement of the patella. The second is the elevation of the bottom of the trochlear groove, where the trochlear groove is too shallow to accommodate the patella. In most cases, both types of abnormalities exist together. Studies have shown that patients with recurrent patellar dislocation have a larger trochlear groove angle than "normal"

J. Zhao (✉)
Department of Sports Medicine, Shanghai Sixth People's Hospital, Shanghai Jiao Tong University, Shanghai, China
e-mail: jzzhao@sjtu.edu.cn

H. Zhang
Sports Medicine Department, Beijing Jishuitan Hospital, Beijing, China

J. Zhao (ed.), *Minimally Invasive Functional Reconstruction of the Knee*,
https://doi.org/10.1007/978-981-19-3971-6_48

patients. Some people believe that the reason for the abnormal femoral trochlea angle is not the abnormal lowness of the lateral femoral condyle, but the abnormal highness of the bottom of trochlear groove. Now, the morphology, development, and articulation of the patellofemoral joint can be evaluated in detail on the cross-sectional images of magnetic resonance imaging (MRI) or computerized tomography (CT) of the knee. However, comparative data on trochlear groove bony structure between the normal population and patients with patella dislocation are lacking.

Patellar Abnormity In the development of patellar dislocation, patellar morphological abnormalities may be more of a cause than a consequence. If the patella remains dislocated for a long time, secondary morphological abnormalities are likely to occur. In many cases, patellar dislocation is the result of a chronic alignment abnormality. Of course, traumatic dislocation of the patella can also occur with complete anatomic and alignment normality. Studies have shown that in most patients with patella dislocation, patella is thin, and most of the patella shape is Wiberg III type.

Abnormal Bone Alignment

Patella-Trochlear Groove Matching Abnormality In patients with patella dislocation, the patella will tilt and displace laterally relative to the trochlear groove. The high and low patella are abnormality in the sagittal plane. This abnormal height relationship of the patella with respect to the femoral trochlea is in most cases attributable to the length of the patellar tendon. There are different opinions about the relationship between patella alta and patella dislocation. Studies have reported that more than half of patients with patella dislocation have patella alta. Insall et al. also believed that patella alta was an important pathogenic factor [3]. As with other abnormalities, patella dislocations are not always associated with patella alta, and a significant number of patients with patella dislocations have normal patella position. Although patella alta can be found with patella dislocation or alignment abnormalities, it is generally considered to be less of a problem than other alignment abnormalities or structural abnormalities.

Abnormal Torsion of Lower Limb In patients with dislocation of the patella, if the ankle is adjusted parallel to the coronal plane, the proximal femur is also along the coronal plane without anteversion of the femoral neck. The torsion within the lower leg occurs at the distal femur and the proximal tibia, which is proximal to the tibial tubercle. (Fig. 48.1) This indicates that the abnormal torsion of the lower limb occurs at the knee. The so-called abnormal proximal femoral anteversion with reference to a normal distal femur is a misinterpretation of abnormal medial rotation of the distal femur with reference to a normal proximal femur. The medial rotation of the knee is corrected at the level of the tibial tubercle, resulting a normal-orienting distal leg. The so-called abnormal lateral deviation and rotation of the tibial tubercle with reference to the normal trochlea groove and the proximal tibia is a misinterpretation of abnormal medial rotation of the trochlear groove and the proximal tibia with reference to a normal tibial tubercle. From this aspect, the tibial tubercle should not be transferred to oppose the abnormal trochlear groove, and the knee should be rotated laterally through osteotomy at the distal femur and proximal tibia, to let the trochlea groove to oppose the tibial tubercle.

To adjust abnormal medial rotation of the knee, single plane distal femur derotation osteotomy is not enough and will cause abnormal external rotation of the primarily normal distal leg. Only through bi-plane osteotomy, which is performed at the supracondylar region of the distal femur and the proximal tibial region proximal to the tibial tubercle and rotate the whole knee backwards, can we correct the abnormal torsion of the knee without disturbance of the normal orientation of the distal leg.

Abnormal Varus or Valgus Alignment in the Coronal Plane The incidence of knee valgus in patients with patella dislocation is not particularly high. Knee valgus is generally not consid-

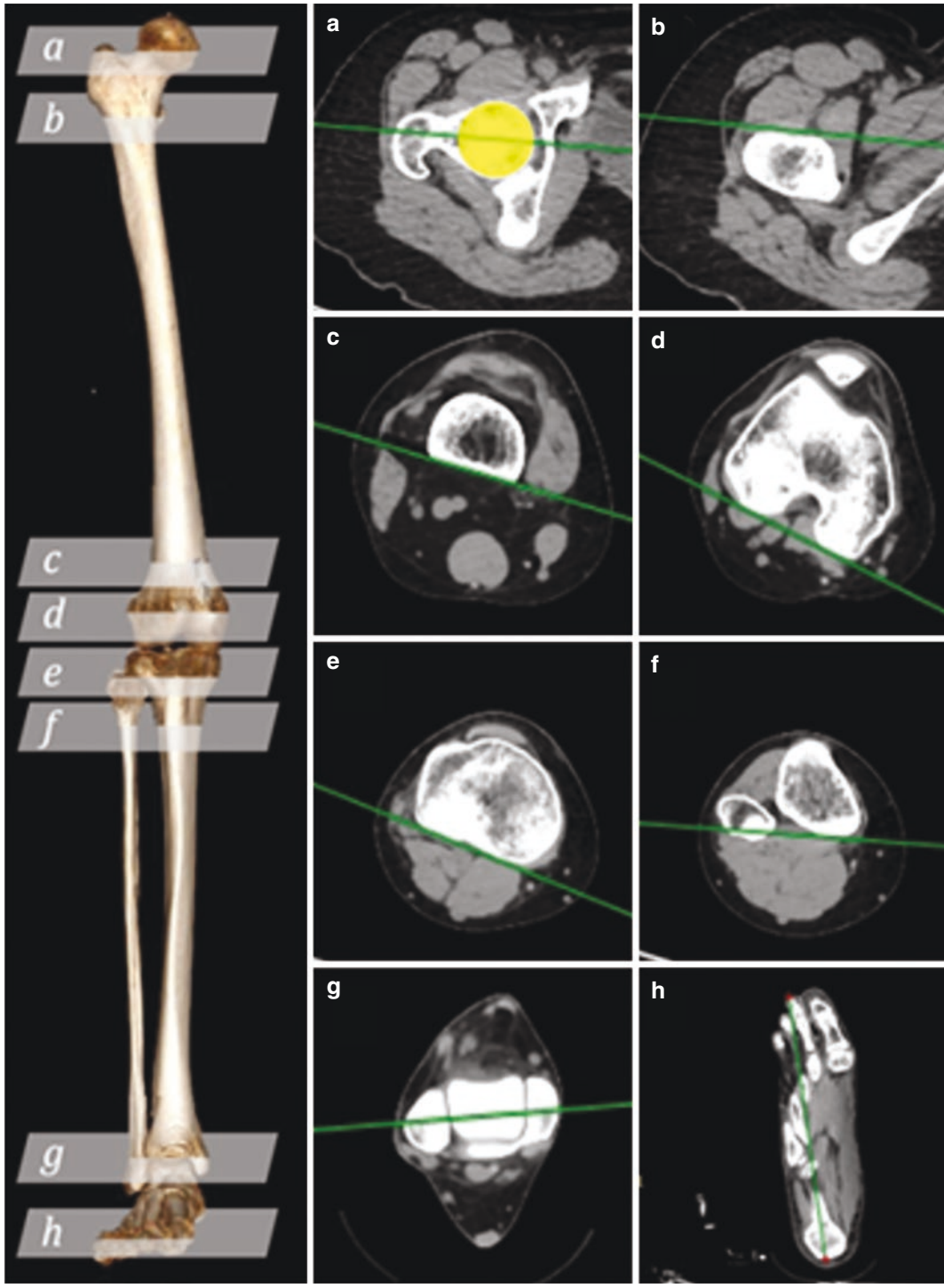

Fig. 48.1 Illustration indicating in patient with recurrent patella dislocation, the tortional deformity occurs mainly at the knee. (**a**) Line through the center of femoral head and femoral neck. (**b**) Line tangential to the anterior aspect of the proximal femur at the level of lesser trochanter. (**c**) Line tangential to the posterior border of the distal femur just over the insertion of the gastrocnemius. (**d**) Line tangential to the posterior femoral condyles. (**e**) Line tangential to the posterior aspect of the tibial plateau. (**f**) Line tangential to the posterior tibial cortex. (**g**) Line through the centers of the medial and lateral malleolus. (**h**) Line through the center of the calcaneus and the third metatarsal head

ered a major cause of patella dislocation because many children with severe knee valgus do not have patella problems. Patients with severe patellofemoral joint disorder may have genu varus, but whether genu varus is the cause of the lateral dislocation of the patella remains to be studied.

Soft Tissue Abnormality

Abnormal Collateral Stabilizing Structure of the Patella MPFL is strengthened by the vastus medialis muscle and appears to play an important role in preventing patella dislocation. MPFL can be torn, or it can be reduced in strength. Koskinen et al. [4] found that in patients with patellar dislocation, the insertion of MPFL is more medial. Whether due to trauma or structural abnormality, patellar dislocation always weakens the medial stable structure when it first occurs, followed by dislocation. Several authors have reported patellar dislocation in patients with general laxity syndrome, including osteochondral dystrophy, Ehlers-Danlos syndrome, and Marfan syndrome. In these cases, the medial stable structure is insufficient to resist the normal lateral-migration of the patella determined by the Q Angle.

Contracture of the lateral retinaculum will undoubtedly aggravate lateral displacement of the patella (LDP) and lateral tilt, thereby increasing the risk of patella dislocation. Heywood's review of 76 patients, however, found no such findings. These studies demonstrate that many factors play an important role in the functional balance of the knee extension device. Jeffries reported three cases of abnormal fascial connection from the iliotibial band to the superior lateral edge of the patella [5].

Quadriceps Imbalance Recurrent dislocation of the patella may also occur after paralysis of the medial femoral muscle secondary to polymyositis. Some patients have medial vastus muscular atrophy or dysplasia. In the latter, muscle fibers attach only to the surface of the patella, not to the upper and medial edges of the patella. In patient with fixed patella dislocation, redundancy of the vastus medialis always exists, which justify distal lateral advancement of the vastus medialis. Abnormal attachment of the vastus lateralis muscle fibers, abnormal fiber bundles in the vastus lateralis muscle, and abnormal contracture of the vastus lateralis as well as the lateral part of the rectus femoris and vastus intermedius play important roles in patella dislocation, which always manifested as a J sign at knee extension and justify quadriceps rebalance [6, 7].

Diagnosis and Treatment of Primary Patella Dislocation in Acute Stage

Patellar alignment abnormalities, especially subluxation of the patella, increase the chance of complete dislocation of the patella. Patellar dislocation refers to the complete displacement of the patella from the trochlear groove, resulting in the loss of articular surface alignment. Patellar dislocation always occurs suddenly, whether due to direct trauma or due to torsional stress of the extension device based on the original alignment abnormality.

Clinical Manifestations in Acute Stage

Patients with acute patellar dislocation are aware of the prolapse of the kneecap. In some cases, the patient himself or with the help of others can put the patella back in place. Sometimes patients complain of "dislocation of the knee," when in fact it is simply a dislocation of the patella. Examiners need to be aware of these "self-diagnoses." Either way, the experience of patella dislocation can leave the patient with the distinct impression that something serious is wrong with the knee. Patellar dislocation can occur during strenuous exercise and direct violence as well as during minor activities. Patellar dislocation typically occurs in young, short women with patellar alignment abnormalities and loosened ligaments, but it also occurs more often in athletes engaged in vigorous activities, both male and female. Some patients may have preexisting anterior knee pain, but it is not severe. Sometimes patients may feel the patella dislocated medially, but actually feel the medial femoral condyle, which is relatively protruded.

The primary clinical presentation of the patient is mainly knee swelling, which often makes it difficult to carry out the relevant physical examination. Combined with the history, the presence of cruciate ligament rupture and meniscus injury in addition to patella dislocation are further determined. Movement of the affected limb is often limited by pain, swelling, and impingement of the detached cartilage mass.

Patients with chronic rupture of the anterior cruciate ligament are always combined with patella instability. In this case, the "giving away" feeling of the patients may be due to either anterolateral rotational instability of the tibia or lateral subluxation of the patella, both occur at slight knee flexion. Both anterior knee instability and patella instability should be corrected, especially when the exact causes of this "giving away" sensation cannot be distinguished.

The integrity of the patella retinaculum and ligament abnormalities should be carefully examined in the extensor position. The cruciate ligaments should be checked for laxity and the meniscus should be checked for tenderness at the joint line. There will be marked tenderness in the area of the medial retinaculum, and patients will have marked fear with lateral pushing of the patella. The integrity of the MPFL should be checked. There will be swelling in the vastus medialis muscle.

Knee extension and flexion may be limited by pain, but if the patient is able to flex the knee to some extent, the lateral deviation of the patella (compared to the contralateral) can be detected or felt. Tender at the lateral retinacular zone is optional. The entire knee extensor device should be examined. Some elderly patients with patella dislocation may experience avulsions of the quadriceps femoris tendon from the upper pole of the patella. There may be a void in the proximal side of the patella, but this may not be visible visually when the entire knee joint is swollen. The patient is asked to do a straight leg raise if possible; if not, the integrity of the knee extension device should be questioned. In this case, the McMurray test cannot be performed, but it is important to check for localized tenderness points and knee instability.

If possible, the patient is required to stand on the ground to examine the lower limb line for valgus and rotation abnormalities. Examination is performed to further rule out excessive laxity of the patient's overall joint capsule and ligaments.

Imaging Findings

Theoretically, when patella dislocation is suspected, the anterior posterior and lateral views of the knee and the 30-to-45-degree axial view of the patella should be taken under the loading condition. On X-ray, signs of lateral patella deviation can be found, either because of a preexisting patella alignment abnormality or because of a tear of the medial retinaculum. Axial view radiographs of the patella can indicate alignment abnormalities. A bone defect may be found at the medial margin of the patella or the lateral femoral condyle. If the osteochondral fracture fragment is free, the bone fragment can be found anywhere in the joint cavity, most often in the lateral sulcus and femoral notch.

Lateral view radiographs are useful for determining patellar inclination and evaluate the extent of trochlear groove development. In the case of complete extension or 30° flexion of the knee, the radiograph should be taken under the condition that the contour lines of the posterior femoral condyle are completely overlapped (fluoroscopic monitoring is carried out before radiograph is taken). The degree of elevation of the trochlear groove can be evaluated according to the relative relationship between the baseline of the trochlear groove and the anterior cortical line of the femur. The degree of dysplasia of the femoral condyle can be evaluated according to the relative relationship between the anterior contour line of the femoral condyle, the bottom line of the trochlear groove, and the anterior cortical line of the femur (Fig. 48.2). However, unless fluoroscopy is first used to determine the posterior overlap of the femoral condyle, it is difficult to obtain an ideal lateral view radiograph. Clinically available lateral radiographs of the knee rarely overlap the contours of the posterior femoral condyles, mainly due to medial rotation of the knee in relation to the lateral view of the ankle. Currently, because of the use of three-dimensional CT and MRI, it is rarely necessary

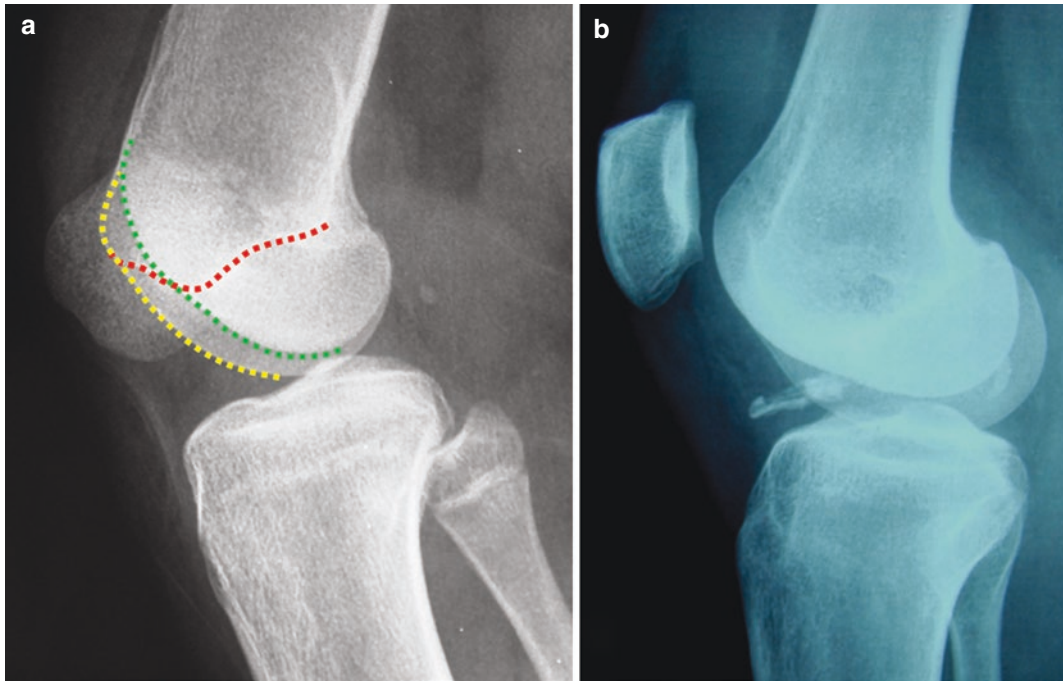

Fig. 48.2 radiographies indicating the evaluation of the trochlea groove. (**a**) On standard lateral view radiography of the knee, the extent of dysplasia of the medial femoral condyle (green line) can be revealed. By the intersection of the trochlea line (red line) and the femoral condyle line (yellow line), the degree of elevation of the trochlear bottom can be obtained. (**b**) The most commonly available clinical images are non-standard lateral view radiography

to use standard lateral view radiographs to evaluate the degree of trochlear dysplasia of the femur [8–10].

CT examination is recommended in patients with primary dislocation. Theoretically, CT at 20–30° knee flexion is helpful in evaluating the functional alignment of the patella and trochlear groove. However, radiologists often have difficulty to accurately set the knee flexion angle. Furthermore, for patients with varying height of the patella, the best knee flexion angle at which the patella engages the trochlea groove varies. Therefore, we routinely performed CT examination at the full extension of the knee. During the CT examination, the patient is required to maintain hyperextension of the knee with the toe pointing upwards. During the maintenance of hyperextension, the quadriceps muscles contract and pull the patella upward, so that the position of the patella above and below the trochlear groove can be evaluated to determine whether there is a patella alta. The extent of the internal rotation of the femoral condyle can be measured in a knee CT with the toe pointing upward (Fig. 48.3). If there is a lot of blood in the joint, it is recommended to puncture and draw the fluid first. When there is fluid in the joint, the patella shows excessive lateral deviation and tilt. The static position of the patella can be known on CT and the probability of recurrence of dislocation can be predicted based on the matching degree of the lateral patellofemoral joint. If the patella is mostly outside the trochlear groove in the static condition, there is a great chance that the patella will be dislocated during force exertion, requiring aggressive treatment.

MRI is also recommended in patients with primary dislocation. In addition to evaluating cartilage injury, MRI examination is more important to evaluate the extent and location of MPFL tear. On medial side of the patella, the MPFL fuses with the medial femoral aponeurosis to form a layer attached to the middle and upper medial margin of the patella. An avulsion of the MPFL near the patella attachment often indicates a loss of connection between the vastus medialis muscle and the patella. In this case, the function of

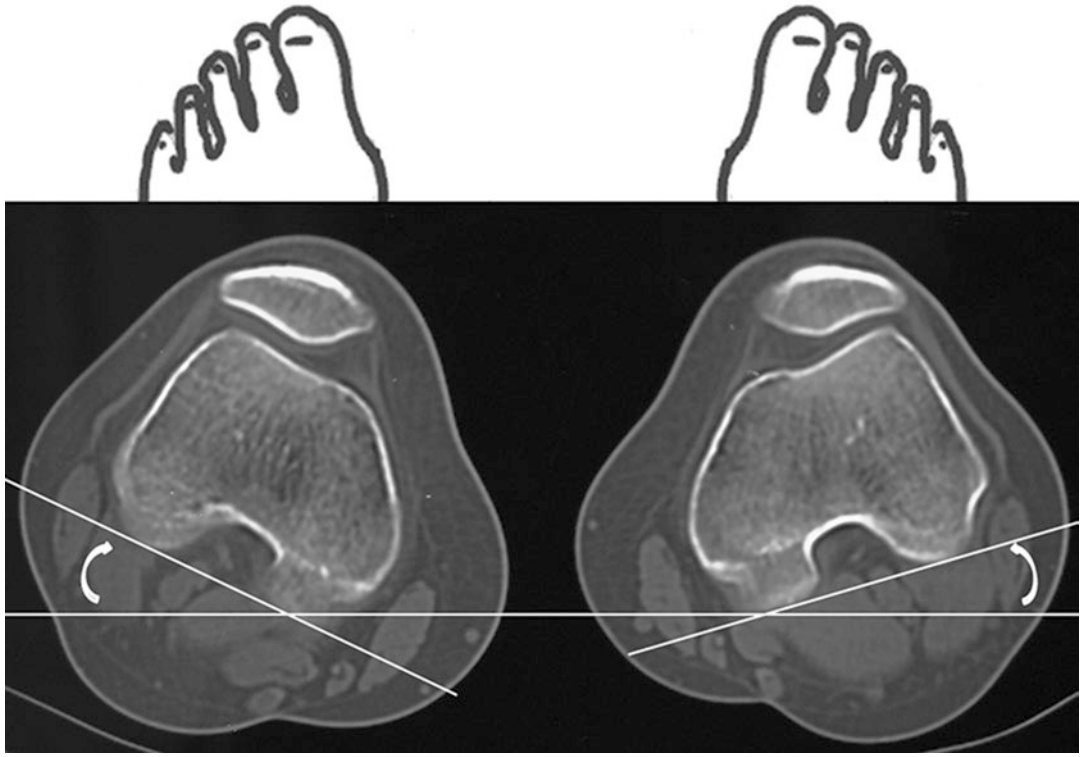

Fig. 48.3 Computerized tomography of the knee with the toe up provides an overview of the degree of internal rotation of the distal femur

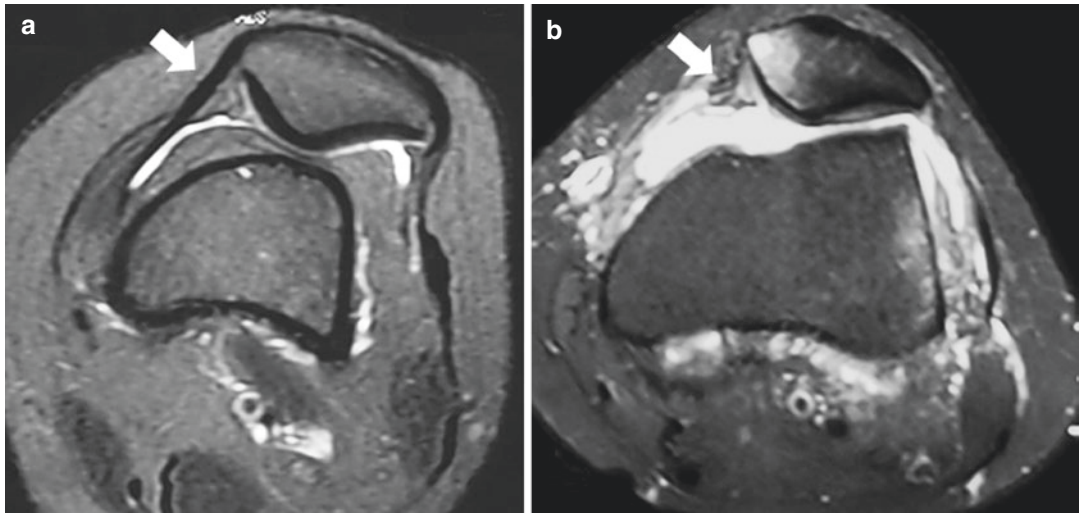

Fig. 48.4 MRI of MPFL in patients with patella dislocation on MRI images of intact (**a**) and injured (**b**) patella attachment

the vastus medialis is lost, and the recurrence of patella dislocation is much higher, requiring aggressive treatment. A middle or medial tear of the MPFL indicates that the vastus medialis muscle connection is intact, and treatment can be conservative (Fig. 48.4).

Treatment of Primary Patella Dislocation in Acute Stage

In principle, the treatment of acute primary patella dislocation should be conservative. The knee is generally immobilized in extension position with a long leg cast or brace for more than 3 weeks. Medial-pushing patella braces can be used. The indications of surgical treatment in the acute phase are (1) intraarticular osteochondral fractures forming joint interlocking, (2) large osteochondral fractures with bone layers need to be reduced and fixed, and (3) the MPFL is avulsed from its patellar attachment.

The fractured bone block caused by patella dislocation is usually located in the lateral sulcus of the knee and is bonded to the lateral femoral condyle or joint capsule without causing interlocking. If the fracture is in the femoral notch or in the anterior compartment of the knee and causes knee extension limitation, or if it is free in the joint and often causes interlocking, surgical treatment, removal of the fracture, or reduction and fixation may be required. The fracture block resulting from patella dislocation mostly comes from the medial side of patella or the lateral femoral condyle, which will cause the change of patella shape and further weaken the block of trochlear groove on patella dislocation. Large defects in the patellofemoral joint cartilage also significantly increase the incidence of patellofemoral arthritis. Therefore, reduction and fixation are necessary for large osteochondral fractures. The fracture block caused by patella dislocation is often irregular, and we recommend reduction and fixation of the fracture block with width greater than 1 cm. If the fracture is cartilaginous, without bone, removal is generally recommended. Subchondral microfracture or drilling with cartilage layer reduction and fixation may also be attempted. Success depends on the ability of the desquamated cartilage to bond to the subchondral bone. If the MPFL is avulsed from one end, especially medial side of the patella, it often implies avulsion of the vastus medialis muscle, and repair is recommended in the acute phase. MPFL is covered by muscle on the femoral side and has a high rate of self-healing. In addition, most avulsions are simple avulsions, and the vastus medialis muscle attachment is complete, so conservative treatment can be tried. If the MPFL injury presents as an avulsion fracture and the fracture displacement is greater than 5 mm, reduction and fixation of the fracture is also recommended. Surgical treatment in the acute phase can be combined with other structural correction or repair procedures, such as lateral retinacular release, MPFL reconstruction, and tibial tubercle transfer.

Diagnosis and Treatment of Primary Patella Dislocation in Chronic Stage

Clinical Manifestations

In chronic stage of primary patella dislocation, some patients have no discomfort symptoms no matter in daily activities or exercise, so conservative treatment is recommended. The mechanism may be that the MPFL injury heals itself, or that the patella has a good original stability mechanism, and the primary dislocation is caused by extreme traumatic stress, or that the stability mechanism is not significantly damaged and the load after reduction is within the tolerable range. However, a large part of the patients has resting pain, loading pain, and instability, either in isolated or combined occurrence status. Resting pain reveals the disturbance of internal environment caused by patella dislocation. This internal environmental disturbance may manifest as cartilage damage, bone contusion, and MPFL laceration. Loading pain is manifested in some patients, which may be related to internal environment disorders caused by patella dislocation and pain over the threshold during load exertion. After the primary patella dislocation in patients with patella instability, there is no recurrence of dislocation, but there is patella dislocation movement when exerting force, which is called patella instability. The process may be the recurrence trend of patella dislocation when exerting force. Patients take empirical avoidance, such as changing or terminating action and exerting force, to avoid the real occurrence of dislocation. The other rea-

son of instability instead of frank dislocation is that the stress is not high enough to cause dislocation. Some researchers call recurrent patella dislocation patella instability, but we generally refer to patella instability as subluxation.

Imaging Examination

Radiography, CT, and MRI are taken as for patients in the acute stage of primary patella dislocation. Bone fragments that cause interlocking and obviously displaced avulsion fracture from the medial side of the patella are detected. As the joint effusion has subside, the static lateral displacement of the patella (LDP) can be evaluated on the CT images.

Evaluating Static LDP Static LDP can be determined on axial radiography or CT at 30° knee flexion. If strict 30° knee flexion is not available, CT with full extension of the knee can be used as a reference. On correlative images, the lateral facet of the trochlear groove (LFTG) is divided into three equal sections, the junction of the medial and lateral facets of the patella (posterior articular ridge, PAR) is identified, and the projection of the PAR on the LFTG is determined. If the PAR projects in the center of the trochlea groove, the patella has no deviation. If the PAP projects on the medial 1/3 of the LFTG and the matching of the lateral patellofemoral joint is greater than or equal to 2/3, then the LDP is defined as grade I. If the PAP projects on the middle 1/3 of the LFTG and the matching of the lateral patellofemoral joint is between 1/3 and 2/3, then the LDP is defined as grade II. If the PAP projects on the lateral 1/3 of the LFTG and the matching of the lateral patellofemoral joint is less than 1/3, then the LDP is defined as grade III. (Fig. 48.5a). Because the representative patella section and the femoral trochlea section are not the same level, the two levels of image should be overlapped to make the evaluation. For patients with negative J sign, the grade of LDP at full extension is like that at 30-degree knee flexion. For those with positive J sign, the grade of LDP at full extension is larger than that at 30-degree knee flexion and static LDP revealed during physical examination is used instead.

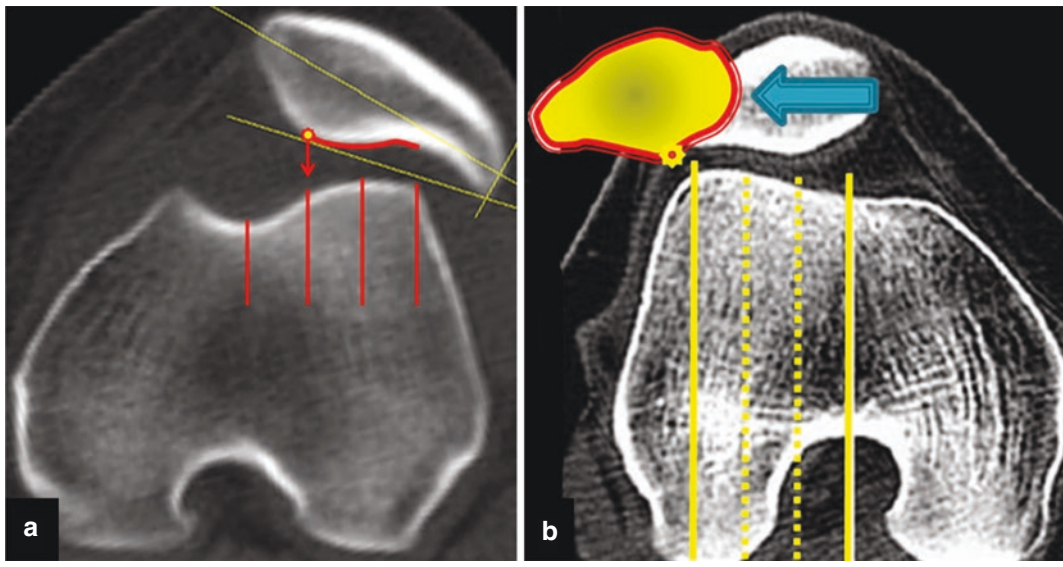

Fig. 48.5 Evaluation of static lateral displacement of the patella on computerized tomography image (**a**) (the lateral facet of the trochlear groove is divided into three trisections and the projection of the posterior articular ridge of the patella on it is defined) and illustration of grade II static and grade III dynamic lateral displacement of the patella (**b**)

Physical Examination

For patients in the chronic stage of primary patella dislocation, the dynamic lateral displacement of the patella and the apprehension test is evaluated.

Dynamic Lateral Displacement of the Patella The knee is flexed to approximately 30°, the patella is pushed laterally with the quadriceps in relaxed status. The degree of lateral displacement of the patella (LDP) is defined with the one quadrant width of the patella as one degree (Fig. 48.5b). In normal knee, the lateral edge of the patella is flush with the lateral surface of the lateral femoral condyle. Four-degree lateral displacement of the patella (LDP) indicates complete dislocation of the patella.

The meaning of dynamic LDP should be interpreted in combination with the static LDP and the cross-section shape of the patella. If the static LDP is two-degree, two-degree dynamic LDP indicates total dislocation of the patella. However, the static LDP is difficult to access clinically, because the best way is CT examination at 30-° knee flexion. Clinically, we first push the patella medially till lateral edge of the patella flush to the lateral surface of the lateral femoral condyle, namely reducing the patella. Then we release the patella, the automatic LDP that happens subsequently indicates the static LPD. The degree of static LDP evaluated in physical examination, which is defined according to the quadrant of the patella width, is different from the degree of LDP evaluated on CT images, which is defined according to the matching of the lateral patellofemoral joint.

The meaning of dynamic LDP depends on the configuration of the medial and lateral facets of the patella. For a Wiberg I patella, in which the lateral patella surface corresponds to 50% of the patella width, two-degree dynamic LPD indicates the PAR rides at the lateral edge of the femoral condyle, even without static LDP. A lucky phenomenon is that most patients with patella dislocation have a Wiberg III patella, which indicates the lateral patella facet corresponds to 75% or all of the patella surface. In these patients, three-degree LDP indicate a patella dislocation when there is no static LPD.

Apprehension Test Apprehension test is to reveal the discomfort and fear of dislocation during the LDP test. It usually occurs when the patella ride over the highest point of the lateral facet of the trochlea groove. As for the diagnosis for patella dislocation, apprehension test poses sensitivity and specificity [11]. Some patients with high degree of LDP have negative apprehension test, and others with low degree of LDP have positive apprehension test. It should also be distinguished with patellofemoral pain resulted from patellofemoral arthritis or inflammation. Usually, the patients who have severe remaining trauma effect from the previous event is prone to be positive in the apprehension test.

Treatment of Primary Patella Dislocation in Chronic Stage

At first, for primary patella dislocation in chronic stage, the surgical indication still exists as for primary patella dislocation in acute stage, which include osteochondral fractures forming joint interlocking, large osteochondral fractures with bone layers need to be reduced and fixed, and the MPFL avulsion fracture from its patellar attachment with over 5 mm displacement. For patients without these surgical indications, the treatment depends on the symptoms and signs, and the physical and imaging examination results (Fig. 48.6).

For asymptomatic patients, regular follow-up is taken mainly to evaluate the development of the static LDP. Patella protecting brace is suggested to use during sports. For patients with resting pain, conservative treatment is suggested, no matter the patient have loading pain and patella instability or not. Physical therapy is recommended, and excessive load is avoided. For patients with resting pain, operation is contraindicated. Otherwise, the resting pain may aggravate.

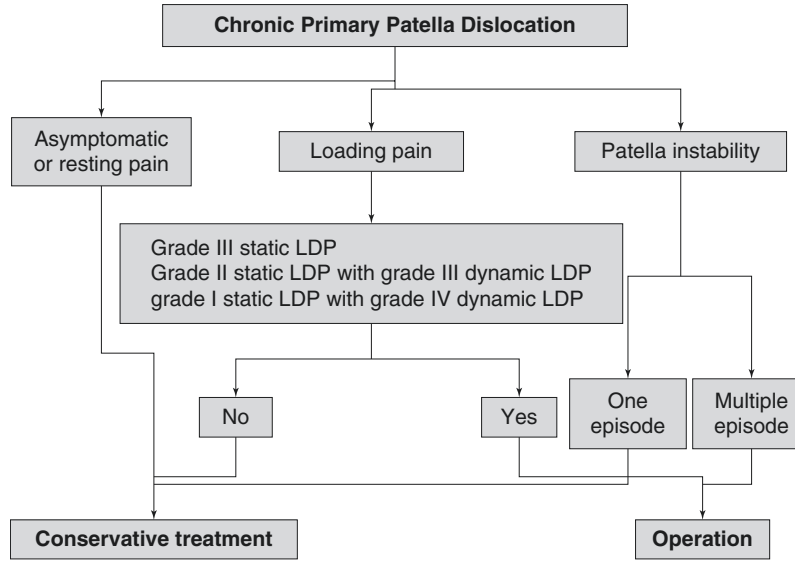

Fig. 48.6 Treatment protocol for primary patella dislocation in chronic stage

For patients with loading pain, conservative treatment is first taken to avoid loading of the lower extremity and expect recovery of the hemostasis of the inner environment and pain threshold. If conservative treatment fails, surgical treatment should be considered, and targeted surgery should be performed to evaluate the characteristics of the structural disorders. If loading pain is accompanied by patella static deviation and patella dynamic instability, comprehensive judgment is needed to determine the treatment. If there is serious static deviation or dynamic instability, the probability of patella dislocation is significantly increased. To avoid recurrence of patella dislocation causing new cartilage injury, surgical treatment is recommended even if there is no recurrence of patella dislocation or instability. In addition, in the case of severe patellar dislocation or static instability, the patellofemoral joint mismatch can cause premature degeneration even without the onset of dislocation, and surgical intervention is also recommended.

Overall, for chronic primary patella dislocation manifested as loading pain combined with static and dynamic LDP, the surgical indications are: (1) grade III static LDP, (2) Grade II static LDP with grade III dynamic LDP, (3) grade I static LDP with grade IV dynamic LDP. The purpose of surgical treatment of loading pain is to restore the stability of patella, correct the patella track, and adjust the load distribution. The specific surgical method needs to be combined with the extent of the structural abnormality.

Patellar instability also causes abnormalities in the cartilage of the patella. Clinically, temporary conservative treatment is recommended for patients with primary patella dislocation following one patella instability attack. For two episodes of patellar instability, they are considered as one full-onset dislocation attack and surgical treatment is recommended.

Diagnosis and Treatment of Recurrent Patella Dislocation

The course of recurrent patella dislocation is complex and varied. Patellar dislocation is a once-in-a-lifetime occurrence in patients, Heywood estimates, accounting for about 15%. Some patients may have only 2 or 3 dislocations over several years, and the patellofemoral joint is stable in the interval of the episodes, thus avoiding surgical intervention. Some patients show frequent dislocations, even often in modest activities or sports, such as walking, climbing stairs, dancing, and so on. There are also complaints of knee instability and discomfort between episodes of dislocation. Crosby et al. followed up 26 patients and reported that the frequency of dislo-

cation attacks decreased with age. However, it is important to remember that severe cartilage damage can occur when the patella is dislocated.

Recurrent patellar dislocation usually occurs in teenagers. The male-to-female incidence ratio is about 5:1. Limb length, alignment, and movement level change at this age. The first dislocation often occurs without warning and may occur with a simple twisting action. Studies have shown that about 40% of patients with dislocations occur during eversion and lateral rotation of sports activities. The clinical manifestation and imaging findings are like primary dislocation.

Some researchers have found that the severity of patella dislocation is related to the long-term prognosis. Patients who have significant pain, swelling, and dysfunction with each dislocation episode, even if it is infrequent, have a worse prognosis than patients who have more frequent but less severe dysfunction with each episode. Therefore, for patients with recurrent patellar dislocation, especially those with severe symptoms, aggressive treatment may improve the long-term outcome.

Clinical Manifestations

For patients in the acute stage of recurrence, the signs and symptoms are like that in the acute stage of primary dislocation, with less severity in most patients. In the chronic stage of recurrence, the signs and symptoms are like that in the chronic stage of primary dislocation, which including knee interlocking, resting pain, loading pain, and instability within the interval of frank dislocation.

Physical Examinations for patients with recurrent patella dislocation, four important physical examination should be taken, which include static and dynamic LDP, apprehension test, J sign, and medial rotation of the knee.

J sign is a special lateral movement of the patella at the end stage of knee extension. It indicates the engagement of the patella in the trochlea during flexion and disengagement and lateral shifting at the end of extension. J sign indicates static or dynamic quadriceps imbalance and justifies quadriceps rebalance. Following routine proximal or distal realignment procedure, patients with J sign are prone to failure when the quadriceps imbalance is not addressed.

For the examination of the medial rotation of the knee, the patient is placed in supine position, the knee is fully extended, the ankle is dorsiflexed, and the foot is placed in upward direction. The medial and lateral femoral epicondyles are palpated and marked. A virtual line is drawn through the femoral epicondyles. The angle between the virtual trans femoral condyle line and the ground surface is estimated. In this way, the medial rotation of the knee can be primarily evaluated.

Imaging Exanimations Routine radiography, CT, and MRI exanimations are taken mainly for the preparation of bony procedures. Three-dimensional CT examination is performed to evaluate the medial side of the medial femoral condyle for the intraoperative location of the femoral tunnel. The TT-TG distance is checked to determine whether tibial tubercle transfer will be performed. The lower limb alignment is measured to determine whether alignment correction should be performed.

Three-joint CT examination is taken to evaluate the medial rotation of the knee to assess the necessity of knee derotation osteotomy. In case the three-joint CT cannot be taken, standard isolated knee joint CT can be taken with the foot in straight upward direction instead to evaluate medial rotation of the knee.

Treatment Strategies for Recurrent Patella Dislocation

Recurrent patellar dislocation often indicates a serious structural abnormality. This abnormality itself may cause abnormal stress and kinematics of patellofemoral joint, resulting in premature degeneration. Relapse of patella instability or dislocation can cause severe cartilage damage. Interval periods of recurrent patella dislocation may be represented by resting pain, loading pain,

or patella instability. According to literature reports, after the second dislocation of patella occurs, about 50% of patients will have a third dislocation within 5 years [12]. Some patients with recurrent patella dislocation may develop into fixed patella dislocation (also known as habitual patella dislocation). Therefore, once a patella dislocation recurs, it is indicated for surgical treatment. Recurrent patella dislocation first requires the repair and reconstruction of the medial restraint structure and may also need to release the lateral retinaculum when it is in contracture, to transfer the tibial tubercle to correct the excessive tibial tubercle-trochlea groove (TT-TG) distance and patella height, trochlear plasty to match the trochlea groove and the patella, quadriceps rebalance in case of quadriceps imbalance, and knee derotation osteotomy in case of severe medial rotational deformity of the knee.

Diagnosis and Treatment of Fixed Patella Dislocation

Fixed patella dislocation refers to the fact that the patella has no contact with the cartilage of the distal femur throughout the extension and flexion of the knee joint. In the extensor position, the patella may be near the midline, but when the knee is flexed the patella remains lateral to the lateral femoral condyle. In adults, a small proportion of fixed patella dislocations are the evolution of recurrent patella dislocations, and most are the legacy of congenital patella dislocations or untreated developmental patella dislocations in childhood.

Classifications

There are two types of fixed patellar dislocation: congenital and acquired. Green et al. believed that there would be congenital patellar dislocation in the embryo or at birth, and there might be a familial genetic tendency [13]. Acquired fixed patellar dislocation refers to an acquired dislocation in which the patella rolls automatically to the lateral side of the lateral femoral condyle when the knee is flexed.

Etiology

Possible causes of congenital patella dislocation include abnormal insertion of muscle or fibrous tissue, and abnormal fibrous hyperplasia. The result is the same, the quadriceps imbalance. When the knee is flexed, the patella is pulled toward the lateral side of the knee joint. The cause of acquired patella dislocation may be related to progressive quadriceps fibrosis. Quadriceps fibrosis is of unknown etiology and occurs only in the vastus lateralis and vastus intermediates, and in rare cases the rectus femoris muscle may also be affected. It is inevitable that the patella will have too much lateral-ward pulling. If the medial stabilizer of the knee is active, the result is limited knee flexion. Once the medial stabilizer is not active, a fixed dislocation occurs.

Clinical Manifestations

As children age, secondary deformities become more severe, including knee valgus, medial rotation of the knee, dysplasia of the lateral femoral condyle, and shortening of the femur. In addition, patella is small, articular surface is flat, also be secondary manifestation. Therefore, early diagnosis and surgical correction of these deformities before they become irreversible are critical. Although quadriceps contracture and acquired fixed patella dislocation may be the same cause, the quadriceps muscle develops fibrosis, and the two phenomena do not necessarily occur simultaneously. Secondary deformities occur very quickly.

The main manifestations of adult fixed patella dislocation are knee extension weakness and difficulty in squatting and standing up. Because the patella is not in contact with the trochlea of the femur, symptoms of patellofemoral arthritis are rarely present. Symptoms are generally milder than those found by radiography and physical examination. Clinically, rapid progression is rare.

Congenital patella dislocation is difficult to diagnose clinically, first, because there is no pain in the child, and because the ossification of

patella only occurs when the patella is 4 or 5 years chronic. Thus, even if there is abnormality in the early stage, it is easy to miss diagnosis. Apparently, the patient has a genu valgus, which can be detected and touched when the knee is flexed. The abnormal fibrous bands can be palpable on the lateral and proximal side of the patella. The patient had reduced extensor muscle strength but is able to bear weight. Some patients presented with flexion contracture and most of the joints had normal passive range of movement.

Acquired fixed patellar dislocation usually occurs between 5 and 7 years of age. The patient had no symptoms and complained of patellar detachment. No flexion contracture and knee extension disorder can be found. The patella is closer to the midline when the knee is fully extended.

Imaging Examinations

After the presence of the ossified physis nucleus of the patella, a fixed patella dislocation is typically seen on radiographs and is easily diagnosed. On the anteroposterior radiographs, the patella is lateral wards; on the lateral radiographs, the patella overlaps with the femoral condyle and the development of the femoral condyle is low; on the axial radiographs, the patella is lateral wards, and the trochlear groove is flat and not obvious. In some patients, the patella is near the midline when the knee is fully extended, which may interfere with the diagnosis. CT and MRI can evaluate the abnormality of patella and trochlear groove shape, and the degree of patella dislocation. Congenital patella dislocation is more severe in the degree of bony abnormality. However, fixed patella dislocation is a diagnose of the spatial status of the patella at knee flexion. All the routine examinations at knee extension provide only indirect evidence. Theoretically, imaging examination at knee flexion is the only method to define this special spatial status of the patella. Clinically, we rely on physical examination instead of imaging examination at knee flexion to make the diagnosis.

Treatment Strategies for Fixed Patella Dislocation

Surgical treatment is the only measure to relieve the symptoms of fixed patella dislocation, but whether to take surgical treatment depends on the patient's requirements for functional recovery. If the patient has a strong desire for functional improvement, surgical treatment can be tried. It needs to be fully explained to the patient that pain and limited mobility are likely to occur after surgery for a fixed dislocation. Preoperative pain is absent because the patellofemoral joint is unmatched and unloaded. Postoperatively, the patellofemoral joint begins to undergo loading, which may lead to pain. In addition, the surgeries for fixed patella dislocation are complicated and traumatic and may cause severe pain. On the other hand, because the entire knee extensor device is located lateral to the femoral condyle rather than anterior to the femoral condyle before surgery, it is shortened relative to the normal knee extensor device. Adjustment of the patella to the front of the knee joint, i.e. inside the trochlea, may result in limited knee flexion. This is particularly likely to occur in a fixed patella dislocation following the transition from a recurrent patella dislocation, because in such patients the femoral condyle is normally developed in size, the base of the trochlea is elevated, and the shortening effect is evident when the knee extensor device is adjusted to normal position.

Congenital or developmental fixed patellar dislocation in childhood often results in no anterior expansion of the femoral condyle, no elevation of the trochlea base, and no relative shortening of the knee extension device after patellar reduction, and therefore no cause for such limited knee flexion. Of course, the complex surgery itself can cause joint adhesion and limitation of knee flexion. Patients need to have a thorough evaluation of the major surgical complications and weigh the pros and cons before deciding whether to undergo surgery.

In terms of surgical methods, the fixation of patella dislocation requires a combination of various techniques, including MPFL reconstruction, lateral retinaculum release, quadriceps rebalance, tibial tubercle transfer, patella plasty, and so on.

Surgical Procedures for Patella Dislocations

There are numerous surgical procedures reported in the literature for patella dislocation. For the adults, we choose MPFL reconstruction to augment the medial static stability structure of the patella. As for patellar avulsion of the vastus medialis, we would like to perform reattachment of the vastus medialis along with MPFL reconstruction. We give up medial retinaculum plication because we found it is extremely unreliable to restore patellar stability in the long run [14]. For patients without medial instability of the patella, we perform standard lateral retinaculum release with caution not to detach the vastus lateralis from the patella. For patients with TT-TG distance over 15 mm, and patella alta or baja, we perform tibial tubercle transfer, with the purpose to reduce the TT-TG distance to 5–10 mm and correct the patella alta or baja. For patients with recurrent patella dislocation and J sign, and patients with fixed patella dislocation, in which quadriceps imbalance is diagnosed, we perform quadriceps rebalance. For patients with medial rotation of the knee over 20°, we perform floating knee derotation osteotomy to correct the abnormal torsion of the knee.

For skeletally immature patients, we augment the medial stability structure with physis sparing MPFL augmentation or reconstruction technique. We give up medial retinaculum plication [15] and MPFL reconstruction with magus adductor tendon transfer or graft hanging on the adductor tendon because we found these procedures lead to high failure rate. We perform lateral retinaculum release for patients without medial instability of the patella. We perform quadriceps rebalance for recurrent patella dislocation and J sign, and patients with fixed patella dislocation.

References

1. Bowker JH, Thompson EB. Surgical treatment of recurrent dislocation of the patella: a study of forty-eight cases. J Bone Joint Surg Am. 1964;46:1451–61.
2. Crosby EB, Insall J. Recurrent dislocation of the patella. Relation of treatment to osteoarthritis. J Bone Joint Surg Am. 1976;58(1):9–13.
3. Insall J, Falvo KA, Wise DW. Chondromalacia patellae. A prospective study. J Bone Joint Surg Am. 1976;58(1):1–8.
4. Koskinen SK, Kujala UM. Patellofemoral relationships and distal insertion of the vastus medialis muscle: a magnetic resonance imaging study in nonsymptomatic subjects and in patients with patellar dislocation. Arthroscopy. 1992;8(4):465–8.
5. Jeffreys TE. Recurrent dislocation of the patella due to abnormal attachment of the Ilio-tibial tract. J Bone Joint Surg Br. 1963;45(4):740–3.
6. Zhang Z, Zhang H, Song G, Wang X, Zhang J, Zheng T, Ni Q, Feng H. A high-grade j sign is more likely to yield higher postoperative patellar laxity and residual maltracking in patients with recurrent patellar dislocation treated with derotational distal femoral osteotomy. Am J Sports Med. 2020;48(1):117–27.
7. Zhang Z, Zhang H, Song G, Zheng T, Feng H. A pre-operative grade 3 J-sign adversely affects short-term clinical outcome and is more likely to yield MPFL residual graft laxity in recurrent patellar dislocation. Knee Surg Sports Traumatol Arthrosc. 2020;28(7):2147–56.
8. Tscholl PM, Wanivenhaus F, Fucentese SF. Conventional radiographs and magnetic resonance imaging for the analysis of trochlear dysplasia: the influence of selected levels on magnetic resonance imaging. Am J Sports Med. 2017;45(5):1059–65.
9. Pennock AT, Chang A, Doan J, Bomar JD, Edmonds EW. 3D knee trochlear morphology assessment by magnetic resonance imaging in patients with normal and dysplastic trochleae. J Pediatr Orthop. 2020;40(3):114–9.
10. Cerveri P, Belfatto A, Manzotti A. Representative 3D shape of the distal femur, modes of variation and relationship with abnormality of the trochlear region. J Biomech. 2019;94:67–74.
11. Hiemstra LA, Kerslake S, Lafave MR. Patellar apprehension is reduced in most but not all patients after successful patellar stabilization. Am J Sports Med. 2021;49(4):975–81.
12. Arnbjornsson A, Egund N, Rydling O, et al. The natural history of recurrent dislocation of the patella: long-term results of conservative and operative treatment. J Bone Joint Surg (Br). 1992;74:140–2.
13. Green JP, Waugh W. Congenital lateral dislocation of the patella. J Bone Joint Surg. 1968;50B:285–98.
14. Zhao J, Huangfu X, He Y. The role of medial retinaculum plication versus medial patellofemoral ligament reconstruction in combined procedures for recurrent patellar instability in adults. Am J Sports Med. 2012;40(6):1355–64.
15. Zhao J, Huangfu X, He Y, Liu W. Recurrent patellar dislocation in adolescents: medial retinaculum plication versus vastus medialis plasty. Am J Sports Med. 2012;40(1):123–32.