19 Knee Injuries in Handball

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19.1 Introduction

Knee injuries are frequent in handball players. They represent the most severe injuries, both because of the frequently prolonged time to return to sport and the potential consequences in the long term. One of the main and most severe injuries is the anterior cruciate ligament (ACL) rupture. A special chapter is dedicated to this topic in this book. The posterior cruciate ligament and cartilage injuries are also treated separately. We ask the reader to refer to these chapters for specific questions, knowing that it was not conceivable to discuss all knee injuries in one chapter. Therefore, deals with the main injuries occurring in handball, either for their frequency or their severity.

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19.2 Epidemiology

Injuries of the lower extremities are frequent in handball players. Most epidemiological studies have shown that the majority of acute injuries in handball are located in the lower extremities, regardless of age and gender [1–3]. The most frequent injuries reported in handball are ankle injuries (8–45%), while the most severe are knee injuries (7–27%). The latter statistics—expressed as the estimated time of absence from full participation in training and match play—are influenced by the high number of anterior cruciate ligament tears. While some ankle injuries, like simple sprains, usually need only a few days to recover, an ACL injury would mostly require surgery, and a long period of rehabilitation before these patients can reach their pre-injury activity level. Langevoort et al. [4] reported that during major competitions, the incidence of lower extremity injuries in men was 42%; knee injuries represented 13% of all injuries, while 11% affected the ankle joint. A recent study by Bere et al. [5] recorded injury and illness surveillance during the 24th Men Handball World championship 2015 in Qatar. They showed that

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58% of injuries were located in the lower extremity (17% ankle, 16% thigh, and only 11% knee). The variance in injury rates which was reported in earlier and recent studies could partially be explained by the development and implementation of prevention exercises handball training. There is a gender difference in ACL injury incidence in handball, with female players suffering four to five times more often than the male athletes [6, 7].

Overuse knee injuries are probably underreported in the literature. Seil et al. [2], reported overuse knee symptoms represented 16% of all overuse injuries, not far behind shoulder injuries (19%) and low back pain (17%). In a study on injury pattern in youth team handball, Olsen et al. [8] reported that 79% of the recorded injuries were acute and 21% were overuse injuries. Knee overuse injuries represented 12% of all overuse injuries and the author mentioned that the percentage is probably underestimated as the study included injuries causing "considerable discomfort." Moller et al. reported on injury rates in 517 elite male and female senior and youth Danish handball, reporting that the knee was the most common site for overuse injuries in adults and the second most common site in youth players [9]. Clarsen et al. studied the prevalence and impact of overuse injuries in Norwegian sports, including 55 handball players [10]. They reported that the knee was the second most common site of injury for overuse injuries (20%) after the shoulder (22%); however, it was the most common site for substantial overuse injuries (8%) compared to the shoulder (6%). The knee was also the second most common site for overuse injuries (20%) after the shoulder (33%) in elite Brazilian handball players [11].

A few studies have compared knee injuries in handball and other sports [12–14]. Majewski et al. [14] documented 17.397 patients with 19.530 sports injuries in 26 different sports over a 10-year period. They reported that 39.8% of the injuries were related to the knee joint. When considering specific knee structures they reported, the highest risk for a structural lesion is seen in handball and volleyball for the ACL and in handball for the PCL.

19.3 Risks Factors

19.3.1 Intrinsic Factors

19.3.1.1 Gender

As previously mentioned, it has been extensively demonstrated in the literature that in handball, women have an incidence of ACL injury which is three to five times higher than in men [2, 7, 15]. Several factors have been highlighted as the main reasons for this difference (i.e., anatomical and hormonal factors, increased physiological knee laxity), and they are extensively discussed in subsequent chapters in this book.

19.3.1.2 Previous Injury

A few studies have shown that previous injury is a risk factor for a new injury [16]. A recently published study from the top two male divisions in Iceland has also shown that previous knee injuries were the only potential risk factor identified for knee injury [17]. Similar findings have been shown in other sports. Nevertheless, more specific handball data are needed to increase the evidence confirming previous injury as a risk factor.

19.3.1.3 Neuromuscular Status and Constitutional Laxity

There is an increased evidence that neuromuscular deficiency can increase the rate of knee injuries, especially ACL injuries. Neuromuscular training programs have proven to be efficient in preventing or at least decreasing the rate of such injuries. These training programs include activities for fitness improvement, sport-specific training and warm-up exercises, muscle strengthening, and improvement of balance and proprioception [18–20].

Physiological anteroposterior laxity and rotational laxity of the knee appear to be a risk factor for noncontact knee injuries, especially ACL injuries [21]. Therefore, players with increased physiologic laxity of the knee may be offered targeted noncontact ACL injury prevention programs. In order to avoid or at least decrease the risk of reinjury, physiological laxity of the knee should be considered when deciding on knee surgery, as well as during the course of rehabilitation and return to sport.

Handball is a sport with high risk of knee injuries; therefore, increased efforts should be directed toward primary and secondary prevention of injuries. Return to play after any knee injury should be decided after medical and physiotherapy clearance: sufficient functional scores for strength and stability and restoration of the injured limb function and core stability [22].

19.3.2 Extrinsic Factors

19.3.2.1 Floor Surface

The shoe-surface interaction is crucial for the quality of the game, but it can also play a role in the incidence of sports injuries. Due to the increased coefficient of friction, the artificial floor poses a greater risk for injuries in handball in comparison with wooden floor [23]. It has been suggested that it might be advisable to wear different types of shoes according to the floor type; however, it is important to note that since this study was conducted, floor types have developed as well as shoe technology and materials.

19.3.2.2 Player Position

Most injuries occur in the offensive part of the game as opposed to defense, when the team has ball possession and control in the opponent's half of the court [5]. Reports have highlighted certain positions to sustain more injuries [15]. Most studies have reported a higher risk for back and wing players [2, 3, 15], while some others identified line players as being be at higher risk for injuries [3, 5].

19.3.2.3 Competition vs. Practice

Although the influence of level of play in handball injuries is still debatable, there is strong evidence in the literature that injuries occur more often during match playing than during training sessions. The overall incidence of all types of injuries has been found to be 4 and 24 times higher during matches [2, 3, 6, 16].

19.4 Medial Collateral Ligament (MCL) Injuries

Anatomically, the MCL is composed of two layers, a superficial and a deep layer. The posterior oblique ligament (POL) has demonstrated to be an important valgus and rotational stabilizer of the knee. The posteromedial structures are a crucial medial knee stabilizer [24]. When making treatment decisions, it is important to consider all injuries of the medial and posteromedial structures.

MCL injuries are frequent in handball; in fact, they account for 7.9% of all sports injuries studied in 26 different types of sports [14], and they can be combined with ACL or PCL tears. Although there are few scientifically validated data on the subject in handball, experience has shown that goalkeepers are particularly at risk for this type of injury. Data from the Norwegian knee ligament registry (NKLR) showed that out of 1548 ACL injuries in handball players, 2.7% were accompanied by an MCL injury. This is comparable to the prevalence in soccer and American football but more than in basketball [12]. An additional 3.6% of handball injuries were classified as multi-ligament, meaning ACL plus at least one other ligament injury from (e.g., PCL, MCL, and/or lateral collateral ligament).

19.4.1 Mechanism of Injury and Diagnosis

There are two common MCL tear mechanisms: (1) a direct contact on the lateral part of the knee with valgus force and (2) a noncontact rotational injury with a combination of flexion, valgus, and external rotation. The noncontact mechanism is particularly common in handball, especially on artificial surfaces, when the foot is fixed on the ground and the body remains in rotation. The player usually reports a sensation of pain and a pop. This mechanism is not very specific for the severity of the injury. Immediate swelling of the knee and inability to walk are other factors of potential severity. Associated injuries, such as a cruciate ligament tear, must always be suspected.

The physical examination should include inspection in a standing position and during gait, swelling, deformity, and ecchymosis, bearing in mind that combined injuries are frequent. With the patient lying in a comfortable position, the MCL is palpated from its femoral insertion to the tibia. A valgus stress test is performed at 0 and 30° of knee flexion. An isolated laxity at 30° is indicative of an isolated lesion of the superficial part of the MCL. Laxity present at 0° of extension is a sign of severity, and an injury of other knee structures should be suspected. Hughston classified laxity in three grades [25]: grade I (laxity less than 5 mm), grade II (laxity between 6 and 10 mm), and grade III when the laxity is more than 10 mm. Theoretically, low-grade MCL injuries can be managed without any additional imaging. Stress radiographs (i.e TELOS) still have a role in higher grades of injury, for recovery assessment and in chronic cases, with easy comparison available to the non-involved side. Ultrasound is an excellent and low-cost tool for diagnosis and follow-up, however is operator dependent. However, with the availability of modern imaging and the pressure of a professional sport environment, MRI, in addition to standard radiographs, allows for an accurate evaluation of the MCL (Fig. 19.1a, b). It is important to mention that the MRI tends to overestimate the lesion, and therefore the treatment must be conducted mainly on the results of the clinical examination [26]. In case of severe medial laxity in full extension, MRI will help the surgical decision-making by allowing for an accurate evaluation of the MCL (proximal or the more rare distal MCL tear, which if a complete tear, could result in a 'stener like lesion') and potential associated meniscus injuries.

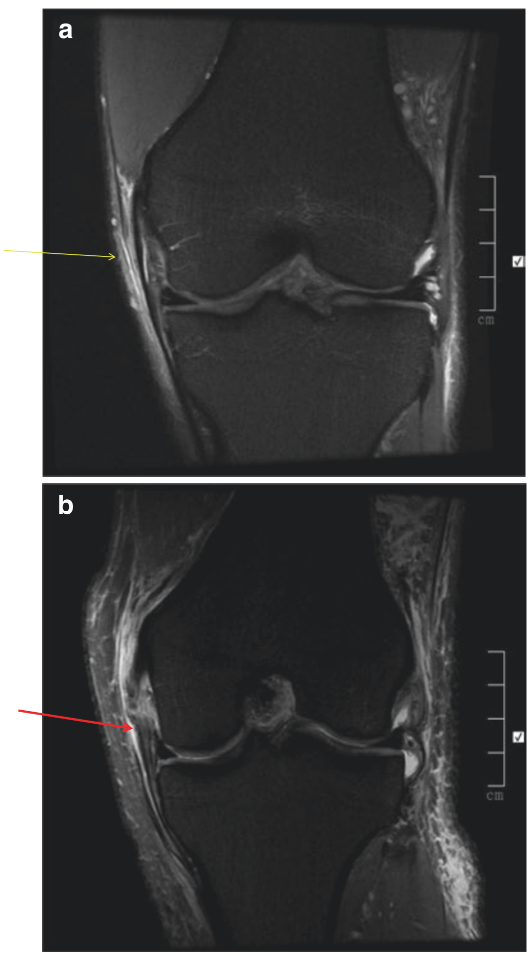

Fig. 19.1 (**a**) MCL sprain grade I. (**b**) Complete tear of the MCL, grade III (Courtesy Dr Maryam Rached AI Naimi)

Some patients may present with chronic MCL injury, complaining of medial knee pain and instability during sports activity. The clinical examination and evaluation of the lesion are the same as with acute injuries. In chronic cases, radiographs must be obtained to rule out a bony lesion or a Pellegrini-Stieda ossification. MRI should be performed for a more accurate soft tissue assessment.

19.4.2 Treatment

The majority of isolated MCL tears are treated conservatively. Grade I injuries (sprain) are treated with RICE and a hinged knee brace for a few days until pain and swelling have improved. Early physiotherapy usually allows the handball player to return to sport within 2–3 weeks after injury, ideally with a functional brace for protection and controlled progression of range of motion. A similar treatment is applied for grade II sprains, with the exception that the brace is applied for up to 3 weeks in order to allow the pain to disappear. For this reason, the recovery of strength and proprioception may take longer. The athlete can usually return to play 6 weeks after the injury.

Nonoperative treatment of grade III MCL injury takes longer. In these patients, it is important to protect the knee throughout the healing process with a hinged brace. Special attention should be given to patients with valgus alignment. The minimum period of immobilization is 4 weeks. During this time, the same protocol of physiotherapy will be applied with control of valgus loading. The main factors for guidance are pain and swelling. Rehabilitation must be more cautious in the presence of a posteromedial knee lesion. Immobilization is gradually discontinued between the 4th and 6th week. During the following 3–6 weeks, the patient can start progressive rehabilitation and sport-specific exercises. Return to sport is rarely possible before 10 weeks in a grade III injury.

Some authors have proposed platelet-rich plasma (PRP) to facilitate and improve the healing process [27]; however no studies were done on humans to our knowledge.

There are still controversies over the place of surgical treatment in isolated grade III MCL injuries [28] in an athletic population. The nonoperative management of a complete tear of the medial structure, including the POL, may lead to residual rotational instability, especially in a pivoting sport like handball. It is then crucial to identify posteromedial lesions either clinically or with MRI scan. When surgical treatment is chosen, diagnostic arthroscopy is performed first in order to assess the intra-articular structures, including the medial meniscus and the site of the deep MCL injury. An open medial approach allows for repair of the deep and superficial MCL, as well as the POL. In patients with chronic MCL injury, who complain of pain and instability in valgus, surgical treatment must be considered for reconstruction of the MCL and POL, after carefully ruling out any associated injuries.

19.5 Lateral Collateral Ligament (LCL) and Posterolateral Corner (PLC) Injuries

Like in other sports, isolated LCL and PLC injuries are generally less frequent than MCL injuries in handball. However, the true incidence is not well known as these injuries are sometimes misdiagnosed and therefore underreported [29]. Their incidence is much higher when they are combined with other ligamentous lesions such as ACL or PCL injuries and may be present in up to 40% [30]. The accurate clinical diagnosis of knee injury in handball is crucial. Misdiagnosis can lead to ineffective treatment and chronic lateral and posterolateral laxity, potentially jeopardizing the athlete's career. In addition, ACL or PCL reconstruction surgery may be compromised if lateral and posterolateral lesions are neglected.

19.5.1 Anatomy and Biomechanics

The LCL, which is also known as the fibular collateral ligament, is attached on the femur, posteriorly to the lateral epicondyle and distally on the fibular head. The PLC consists of various structures including the LCL, the popliteus tendon (PT), the popliteofibular ligament (PFL), and the posterolateral capsule which is reinforced by the arcuate ligament (AL). The PLC serves to resist varus angulation, external tibial rotation, and posterior tibial translation [31, 32] (Fig. 19.2).

19.5.2 Clinical Diagnosis

During clinical examination, the injured knee must always be compared to the opposite knee since some players have physiological lateral laxity without any symptoms. It is important to do a thorough knee examination after any handball knee injury, especially to detect the presence of a posterolateral laxity. In most patients, the cause of this type of injury is a noncontact mechanism, combining hyperextension, varus, and external rotation. But in some cases, it can be the result of a direct medial trauma. This kind of injury mech-

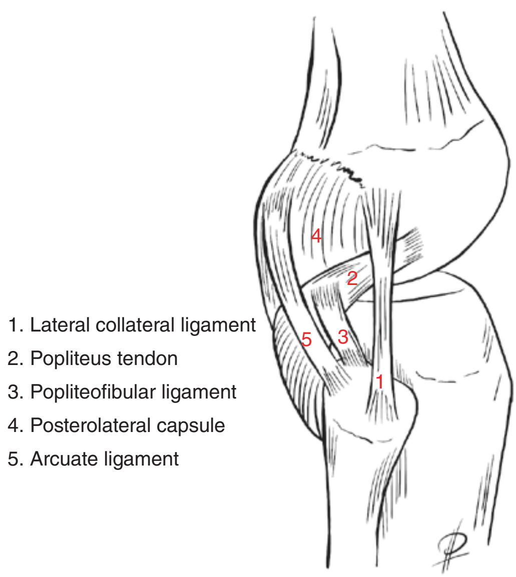

Fig. 19.2 Simplified anatomy of the posterolateral corner of the knee

anism can cause either isolated or combined ACL and PCL injuries. The trauma cascade can reach until the worst case of a knee dislocation. Some of them may be missed because they reduce spontaneously on the field. Combined vascular and/or neurologic injuries must always be suspected with these major severe knee injuries. The clinical examination must focus on assessing the integrity of the peroneal nerve and the popliteal vessels. Limb alignment must be assessed, especially if a varus deformity is present. Gait may be easily assessed in chronic cases. In an acute setting, it can be analyzed at best a few days after the injury. It will provide information about any dynamic varus alignment or the combination of hyperextension and varus deformity during the stance phase.

LCL and PLC injuries should be suspected in the presence of swelling, ecchymosis, and tenderness at the posterolateral aspect of the knee, hyperextension of the injured knee, varus laxity at 30° of knee flexion (LCL tear), varus laxity at 0° of knee flexion (suspicious for PLC injury and cruciate ligament injury), a positive dial test (more than 10° of side-to-side difference in external rotation, suggesting a PLC injury), external rotation recurvatum test (external rotation of the tibia when the knee is in hyperextension), posterolateral drawer test (suspicion of popliteal tendon and popliteofibular ligament injury), and reverse pivot shift test (reduction of the posterior subluxation of the lateral tibial plateau when the knee returns close to extension) [33] (Fig. 19.3).

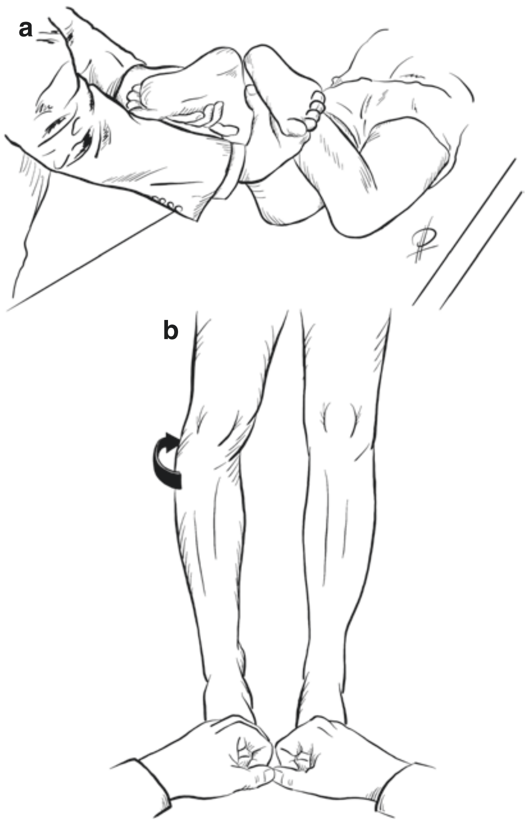

Fig. 19.3 (**a**) The dial test. More than 10° of external rotation in the injured knee compared to the uninjured, suggests PLC injury. (**b**) The recurvatum test: external rotation and varus of the tibia when the knee is in hyperextension

19.5.3 Imaging Assessment

Standard radiographs are performed to exclude any bony avulsion or combined fracture. Stress radiographs are used by some centers for objective laxity assessment [34]. MRI provides the best imaging assessment of the posterolateral structures, allowing an accurate evaluation of the lesion, which is especially important for preoperative planning.

19.5.4 Treatment Decision-Making

The decision between conservative and surgical treatment depends on multiple factors such as the degree of laxity, knee alignment, combined injuries, the time passed from injury, and the level of the handball player. One of the most popular classification systems has been proposed by Hughston [35]. It is easily applicable in clinical practice and is based on the degree of laxity (grade I, 0–5 mm; grade II, 5–10 mm; grade III > 10 mm). Laxity must always be compared to the opposite knee. There is some consensus about the treatment of grade I and III lesions with the first being treated conservatively and the latter surgically. The treatment decision-making with grade II is more difficult, and each case must be evaluated separately taking into consideration the factors mentioned previously. Conservative treatment consists in a short period of immobilization to allow the pain and swelling to decrease. Physiotherapy can be started after a few days. Return to play can usually be considered at 8–12 weeks after injury. Surgical repair for acute grade III injuries should be performed within the first 2 to 3 weeks after injury. By then, the hematoma and swelling have decreased and soft tissue scarring still allows to identify the injured soft tissue structures. Efforts must be done to avoid missing this window of opportunity to treat these lesions by primary repair which has shown better results than chronic repair or reconstruction [36]. Some authors advise to wait until 5 or 6 weeks after a period of rehabilitation in order to decrease the risk of arthrofibrosis. There is currently a debate on the ideal treatment approach, because some of these lesions are difficult to repair. Therefore, some authors propose reconstructions instead of simple repair procedures, both in acute and chronic settings. Particular attention must be given to restore the LCL, the popliteus tendons, and the popliteofibular ligament, as these three structures seem to be the most important static stabilizers of the posterolateral side of the knee. It has been shown that persistence of varus alignment after posterolateral knee repair or reconstruction can lead to failure. Therefore, the accurate assessment of the varus before surgery is mandatory. In case of a significant malalignment, a high tibial osteotomy (HTO) may be considered, either isolated or in combination with a posterolateral ligament reconstruction. However, return to high-level sports has rarely been reported after HTO in such cases. The surgery can be done in one or two stages. In two-stage procedures, HTO is recommended first. A secondary ligament reconstruction procedure may be added after consolidation. In some selected cases, HTO can provide sufficient knee stability, especially in low-demand patients [37].

19.6 Meniscus Injuries

Meniscus injuries are common in handball. Their function is crucial, especially for sporting activities. Partial or total loss of the meniscus leads to biomechanical abnormalities which may significantly affect sports careers in the short and long term. An in-depth comprehension of their anatomy and their biomechanical role is essential to understand their function and to decide on the best treatment in handball players.

The two menisci are semilunar and wedge-shaped fibrocartilaginous structures located between the femur and the tibia. Their congruence with the femoral condyles and the tibial plateau, as well as their connection with some capsuloligamentous knee structures, plays an important role in providing biomechanical function of the knee. Their histological constitution allows to understand their mechanical role. Large collagen fiber bundles run longitudinally from the anterior to the posterior horn where they are fixed to the tibial plateau. These insertional zones are called meniscal roots. The bundles are tied together by radial fiber bundles. The main function of the meniscus is shock absorption which is achieved through a transformation of axial compressive loads into radial forces. On the surface of the meniscus, collagen fibers of a smaller diameter are arranged randomly to disperse the shear stress induced by the flexion and extension of the joint. The space between the fibers is filled with cells and an extracellular matrix made of proteoglycans and glycoproteins. The blood supply of the menisci comes from their periphery, and only the outer 30% of the meniscus is vascularized [38]. The meniscus is divided into three zones: the vascularized red-red zone is located in its periphery, providing good healing potential after repair, the red-white zone has intermediate vascularity, and the white-white (central) zone is avascular. The medial meniscus is longer than the lateral meniscus in the anteroposterior direction, and it covers 50% of the medial tibial plateau. The lateral meniscus covers 59% of the lateral tibial plateau [39]. The lateral meniscus carries most of the load transfer on the lateral compartment, while the load transmission in the medial compartment is more distributed between the cartilage surface and the medial meniscus [40]. Both menisci provide joint congruency, load transfer, pressure distribution, impact absorption, secondary stabilization, joint nutrition, and lubrication.

The surface of the lateral tibial plateau is convex, whereas the medial side is concave. For this reason, lateral meniscectomy will result in proportionally greater contact stress and higher risk of cartilage damage and osteoarthritis compared to the medial compartment [41]. The role of the menisci as secondary knee stabilizer is well recognized [42]. The posterior horn of the medial meniscus acts as a brake to control anterior tibial translation, and the lateral meniscus has a role in controlling internal tibial rotation [42, 43].

19.6.1 Epidemiology, Mechanism of Injury, Symptoms and Physical Examination

Meniscal injury was recently reported to be the most common musculoskeletal injury, with a frequency of 23.8/100000 per year [44]. Medial meniscus tears are more frequent than lateral meniscus injuries in handball players. The treatment approach greatly differs, depending on the type of injury. It is crucial to differentiate between an acute meniscus injury after a traumatic event (which is frequent in handball players) and degenerative meniscus lesions (which are more common in older players).

The most common mechanism of meniscus injury is a twisting movement, generating torsional or axial loading, including valgus and external rotation of the tibia. This mechanism can also cause an ACL tear at the same time. Another typical mechanism is the transition from hyperflexion to extension with entrapment of the meniscus tissue between the femur and the tibia. Clinically, acute tears present with sudden pain, which is usually located on the joint lines. Patients may present with effusion, but this is not specific for meniscal lesions. They can report mechanical symptoms, such as intermittent or permanent intra-articular clicking or true locking of the knee.

In case of degenerative lesions, symptoms are of a more chronic nature. The player often reports recurrent pain with effusion, typically in the absence of an injury. The presence of mechanical symptoms such as clicking and locking is important to be noted, because it can influence the treatment decision. Some degenerative meniscus lesions are asymptomatic, and they may be identified accidentally on MRI which may be performed for another reason. They should be left alone.

A meniscus tear must be suspected particularly when the patient reports pain localized along the joint line, provoked, or increased by hyperflexion, directional change during walking, crossing legs when seated, or when catching one's foot on an irregular surface. The patient often complains of mechanical symptoms such as "clicking" or "catching," recurrent effusion or "locking" with mechanical block to extension.

When a meniscus tear is suspected, the physical examination should include assessment of gait, mobility, laxity, limb alignment, evaluation of effusion, as well as assessment of the patellofemoral joint. This general examination should be followed by specific meniscus tests [45]:

- **Joint line tenderness on palpation** typically reproduces pain or discomfort.
- The **McMurray test** is performed with the patient in a supine position; the knee is extended from fully flexed position while internally rotating the tibia. The test is repeated while externally rotating the tibia. The aim of this maneuver is to impinge the meniscus between the femur and the tibia. Tenderness and/or crepitation along the joint line indicates a positive sign (Fig. 19.4).
- The **Apley test** is another test causing meniscus compression and grinding between the two bones. The patient is lying in a prone

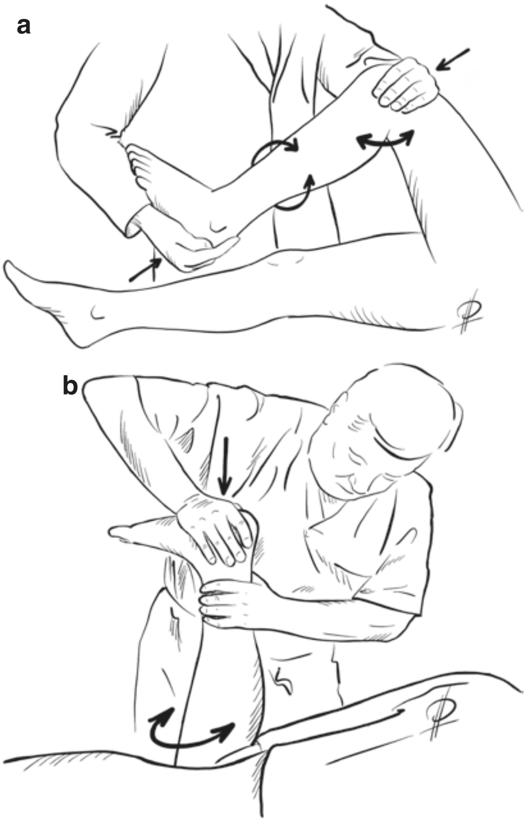

Fig. 19.4 (**a**) The McMurray test. (**b**) The Apley test

position with the knee flexed at 90°. The tibia is compressed on the distal femur, rotated externally and internally to assess the medial and lateral meniscus. This test is considered positive if it produces pain which is less severe or relieved when the maneuver is repeated with distraction of the tibia.

- The **Thessaly test**. This test has been described more recently [46]. The patient is in single-leg stance, flat footed on the affected knee. Under assistance of the examiner, the patient axially rotates the knee several times in 5 and then 20° of knee flexion. The test is considered positive when it provokes medial or lateral joint line pain or mechanical symptoms.

Among these tests, the joint line palpation has been identified as the most sensitive and specific for isolated meniscus pathology during the physical examination [46, 47]. The Thessaly test has been shown to stipulate high accuracy, but the evaluation of this test is still quite limited [46].

19.6.2 Imaging

In most cases, history and physical examination would allow to suspect isolated meniscal pathology. Nevertheless, it must be confirmed by imaging assessment; plain radiographs combining weight-bearing AP, lateral, and Merchant patella view should be the first line in an imaging study. The 45° PA weightbearing view is also highly recommended. Any sign of an early stage of osteoarthritis may indicate the presence of a potential degenerative meniscal tear.

MRI is the most accurate imaging assessment in the diagnosis of meniscal lesions [48], and it is noninvasive. It allows visualizing not only the meniscus but the surrounding soft tissue and capsular ligament as well as assessing the cartilage and the subchondral bone. High signal within the meniscal substance indicates meniscal pathology. An increased internal signal ending at one of the articular surfaces of the meniscus is a strong indicator of a meniscal tear. The specificity of this sign is improved if the increased signal is visible on more than one adjacent image [49].

The sagittal, coronal, and axial sequences usually allow defining the shape of the tear: vertical, horizontal, radial, or the classic bucket handle tear with double PCL sign where the displaced meniscus tissue appears as a second line parallel and anterior to the PCL (Fig. 19.5).

The imaging diagnosis of posterior meniscus root tear can be more challenging [50]. Posterior lateral meniscus root tear usually occurs in association with ACL injuries. Posterior medial meniscal root tears are often of degenerative nature, but they can be observed with isolated axial compression and torsional trauma as well as in cases of multi-ligament injuries. In case of posterior root tear, the MRI may show anteromedial meniscal extrusion and sometimes the classical “ghost sign” (absence of the posterior

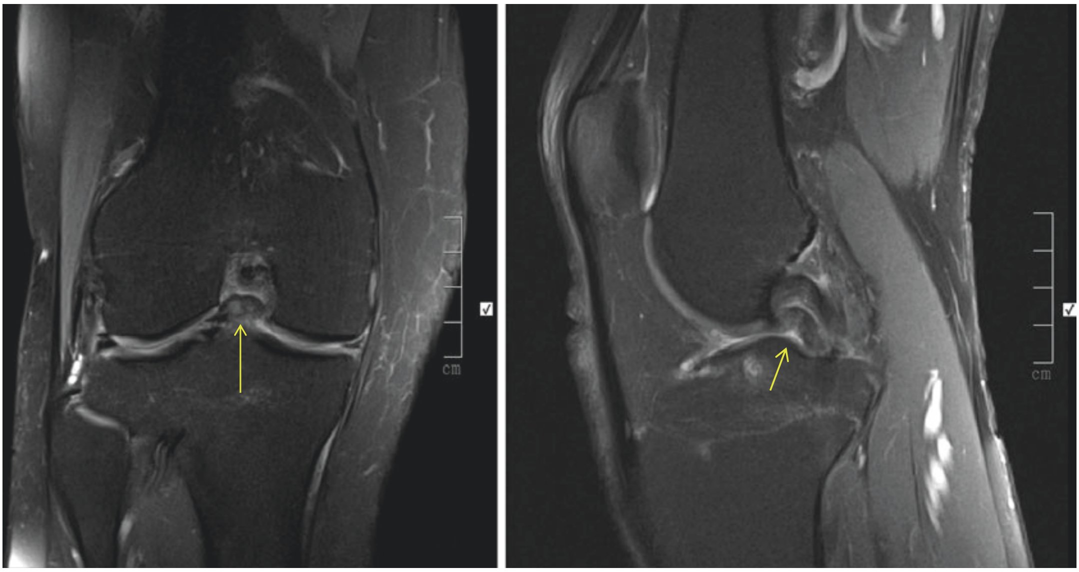

Fig. 19.5 Bucket handle tear of the medial meniscus with (**a**) Meniscal fragment visible in the notch on coronal view. (**b**) "Double PCL sign" on sagittal view (Courtesy Dr Maryam Rached AI Naimi)

horn of the medial meniscus) (Fig. 19.6). The axial view can show a linear defect at the bony insertion of the meniscal root.

19.6.3 Treatment

Even if meniscectomy is still frequently performed, recent studies are in favor of meniscal repair over partial meniscectomy, when considering clinical outcome and risk of osteoarthritis [51]. For the reasons already mentioned previously (load transferred by the lateral meniscus in comparison with the medial meniscus), the effect of a lateral meniscectomy is less "forgiving" than a medial meniscectomy. It explains that the delay of return to sport is longer after lateral meniscectomy and the risk of further osteoarthritis more important. Therefore, meniscectomy should be considered with great care, especially for the lateral meniscus. Paxton et al. [51] concluded in his study that whereas meniscal repairs have a higher reoperation rate than partial meniscectomies, they are associated with better long-term outcomes. Therefore, the concept to "save the meniscus" must be followed, especially in young handball players. Choice of treatment will depend on age, activity level, location, size, tear pattern, chronicity of the tear, combined injuries (ACL injury), and potential healing.

Fig. 19.6 Posterior medial meniscal root avulsion with the "ghost sign" (absence of the posterior horn of the medial meniscus) (Courtesy Dr Maryam Rached AI Naimi)

Meniscus lesions which are localized in the red-red zone should be repaired. This is especially true for those lesions which are repaired in conjunction with ACL reconstructions, because they have a higher healing potential than isolated repairs. In cases of lesions in the white-white zone, simple partial meniscectomy is usually performed. With lesions in the red-white zone, treatment decisions can be more challenging. Healing of these lesions could be promoted using different methods, like perforations or trephinations reaching into the vascularized area and potentially encouraging cell migration to the tear site. Fibrin clot can be used in combination with rasping of the vascularized parameniscal synovium. More recently, platelet-rich plasma has been used to improve the meniscal tear healing [52], but evidence of its efficiency is still lacking. Vertical and bucket handle tears are usually easily repairable. Small radial tears are considered as non-repairable. Complete radial tears induce a complete loss of the biomechanical function of the meniscus. Therefore, repair must be attempted especially in young players, even if it is a challenging procedure [53]. Horizontal cleavage tears have been classically resected. However, some recent studies have shown that repair can lead to good subjective and objective results in the short and long term [54]. Traumatic root tears, which are more often observed in the lateral compartment in combination with ACL tears, should be repaired in young patients. Transosseous tunnels or an all-inside technique can be used [50]. Meniscus replacement, either by meniscal allograft transplantation or by a scaffold, is usually performed in cases of chronic, total, or partial meniscus defects. These situations can occur at the end of the handball player's career, and currently there is no evidence that surgical procedure can allow professional handball players to return to the same level of sport [55].

19.6.4 Result and Return to Handball After Meniscus Repair or Meniscectomy

Partial meniscectomy provides good short-term results, and athletes usually return to pre-injury level of performance. However, results seem to deteriorate with time especially concerning the lateral meniscus [56]. It has been shown that all-inside meniscus repair can provide long-term protective effects even if the initial healing is incomplete [57]. In general, healing rates after meniscus repair are complete in 60% of the cases, partial healing in 25% of the cases, and failure in 15% of the cases [57]. Therefore, meniscus repair must be attempted if there is a potential for meniscus healing. The treatment decision can be challenging, especially in high-level professional athletes as the return to sport after an isolated meniscus repair is longer (minimum of 4 months) as compared to partial meniscectomy. The risk of lower, medium-term results after meniscectomy must be clearly communicated to the athlete, his or her medical team, and the coach. In cases when a meniscus tear is addressed during ACL reconstruction, only clearly irreparable meniscus lesions must be resected during the ACL reconstruction. The reason for this is that the rate of meniscal healing is high when performed in conjunction with intra-articular ACL reconstruction [58].

19.7 Quadriceps and Patella Injuries

19.7.1 Quadriceps and Patellar Tendinopathy

The "jumper's knee," a classic term for quadriceps and patellar tendinopathies, was described by Blazina in 1973 [59]. This pathology is common among athletes involved in jumping activities, and it is more often seen in a male than in a female population. It is particularly frequent in volleyball players (40%). In female handball players, the reported prevalence was 10%, compared to 30% in male players [60]. So far, no specific morphological risk factor has been identified for this pathology. But it has been shown that extrinsic factors play a role in the incidence of quadriceps and patellar tendinopathy, overuse being a major risk factor for tendinopathy. It appears that the field type and a player's higher explosive strength can be a risk factor as well [61].

Fig. 19.7 Proximal patellar tendinopathy (Courtesy Dr Maryam Rached AI Naimi)

The main symptom of jumper's knee is pain. Three pain locations have been observed in sports, the patellar tendon insertion on the distal pole of the patella (70% of the cases), the distal attachment of the quadriceps tendon on the superior pole of the patella (20%), and less frequently on the distal attachment of the patellar tendon (10%) (Fig. 19.7).

Standard radiographs can show insertional calcifications. MRI shows modifications of the intratendinous signal close to the insertional site. Ultrasound has become more popular in the assessment of tendinopathy, with the added value of allowing evaluation of the tendinous vascularization.

Treatment of jumper's knee is mainly conservative. Nonsteroidal Anti-inflammatory Drugs can be used in the acute phase, although corticosteroid injections were commonly used in the past [62]. Due to the high risk of tendon rupture, they are currently not recommended. Other treatment modalities have been proposed such as PRP injections, shockwave therapy, laser, and magnetic therapy although further higher level of evidence studies is necessary to properly evaluate their effects [63]. Currently, physiotherapy is the gold standard in the treatment of jumper's knee with special emphasis on eccentric exercises [64]. Surgery should be considered only after failure of conservative therapy. The objective of surgery is to induce and promote healing in the pathological area of the tendon. Common procedures vary and can combine splitting of the tendon fibers, partial disinsertion, tendon scarification, patellar drilling, and resection of the pathological tissue. The procedure can be performed either open or arthroscopically [65]. Surgery is followed by a short period of immobilization and early physiotherapy. Return to sport may be expected around 4–6 months after surgery.

19.7.2 Patellar and Quadriceps Tendon Rupture

Patellar tendon rupture can be the ultimate consequence in the spectrum of chronic patellar tendinopathy [66]. The athlete usually feels a sudden sharp pain and sensation of tear/rupture in the anterior part of the knee, usually while jumping or landing. There is a complete loss of function, followed by severe effusion and ecchymosis. It is not always preceded by the typical jumper's knee symptoms; however, these should be assessed when obtaining patient history. The diagnosis of patella tendon rupture is based on clinical examination and history. It is also important to inquire about previous intra-or peritendinous corticosteroid injections. Evidence of a palpable gap between the patella and the tibial tuberosity confirms the diagnosis. The patella often appears more proximal when compared to the contralateral knee, and the patient is unable to actively extend his knee due to extensor mechanism insufficiency. Prior to surgery, ultrasound or MRI is recommended to confirm the diagnosis and to allow for a better understanding of the tear pattern.

Quadriceps tendon ruptures have a similar clinical onset but are more frequent in older athletes. The clinical symptoms are similar, but the tendinous gap is either visible or palpable proximally to the patella. Care should be taken not to miss the diagnosis in those patients with partial quadriceps tendon tears and an incomplete functional loss of the extensor mechanism. These patients are still able to actively extend the knee but with less power than normal. Radiographs show a high-riding patella in cases of patella tendon rupture and patella baja if the quadriceps tendon is torn. Ultrasound and MRI usually confirm the diagnosis and provide more information about the quality of the tendon. Surgical repair is mandatory in case of a complete tear. It consists of suture of the tendon combined with transosseous fixation. In the postoperative period, it is recommended to immobilize the knee in full extension for 6 weeks. Initiating physiotherapy will depend on the quality and strength of the surgical repair and should be prolonged until return to sport, which is rarely possible before 6 months [66].

19.8 Patellofemoral Instability

Patellar instability is defined as an abnormal movement of the patella in the patellofemoral groove. It is characterized by subluxation or true dislocation in the coronal plane, predominantly in the lateral direction. Patients with recurrent episodes of patellar instability are found to have specific risk factors. Acute patella dislocation represents 2–3% of all knee injuries [67]. The literature reports recurrence rates of 15–60% [68].

19.8.1 History

The mechanism of injury can be a direct trauma on the medial part of the knee, but it is due more frequently to an indirect injury combining rotation, quadriceps contraction, and valgus. The patella often reduces spontaneously with extension of the knee. Sometimes the patient can reduce it himself by pushing it back into place, or assisted reduction is required. Such trauma is usually followed by swelling and pain.

19.8.2 Risks Factors

Handball by itself is a risk factor due to the frequently sustained contact and noncontact injuries with this kind of sport. Patella dislocations are more common in adolescence and young adults. The peak incidence of patellar dislocation is between 15 and 19 years of age [69]. Females seem to have a higher risk for patella dislocation than males [68].

19.8.2.1 Osseous Factors

A valgus knee increases the lateral force vector on the patella. An increase of femoral anteversion combined with external tibial torsion will also increase this laterally directed force. The patella is a sesamoid bone which is stabilized medially and laterally by the two surfaces of the femoral trochlea. The lateral trochlea ridge is larger, more proximal, and more anterior than the medial trochlea, and it prevents lateral patellar excursion. Anatomical variations such as trochlear dysplasia, meaning a shallow, flattened, or even convex trochlear groove and hypoplasia of the lateral femoral condyle decrease the control of the lateral displacement of the patella. Patella alta is another risk factor as the patella engages in the trochlea quite late during knee flexion. An abnormal lateral position of the tibial tuberosity with its patellar tendon attachment will contribute to the lateral displacement of the patella.

19.8.2.2 Soft Tissue Factors

The medial patellofemoral ligament (MPFL) is a retinacular band of tissue located between the superomedial aspect of the patella and the medial femoral epicondyle. This anatomical structure is a primary restraint of lateral patellar displacement, especially during the first degrees of flexion. It is frequently damaged during the first episode of lateral patellar dislocation. A slack MPFL will be a risk factor for recurrent patellar dislocation. The vastus medialis obliquus (VMO) is an important dynamic medial patella stabilizer. Weakening of this muscle can predispose to lateral patellar dislocation. It should therefore be strengthened during physiotherapy for lateral patellar instability [70].

19.8.3 Clinical Examination

Clinical examination after an acute episode of patellar instability can be difficult. Knee range of motion is quite often limited due to pain and effusion which that can be significant. Aspiration of the hemarthrosis facilitates the physical examination and confirms an intra-articular injury. The area around the MPFL and the medial border of the patella are usually painful during palpation.

In cases of chronic instability, the patient must be assessed in a standing position and observed for morphological abnormalities including genu valgum, hindfoot valgus, pronation of the foot, and malposition of the patella or "squinting patella." Gait and rotation of the hip joint must be analyzed as well.

There are several clinical tests that can suggest patellar instability. During the **apprehension test**, the patella is pushed laterally by the examiner. In case of patellar instability, the patient would have a sense of apprehension. For the **J-sign**, the patient is asked to actively extend his knee from 90°. The test is considered positive if the patella shifts suddenly laterally as it goes over the proximal edge of lateral trochlea ridge. The **patella glide test** is performed with the knee in full extension and relaxed quadriceps. The patella is translated in the mediolateral direction by the examiner. The displacement is quantified with the quadrant method and must be compared to the opposite knee to evaluate the significance of lateral patellar displacement.

19.8.4 Imaging

Radiographs, including standing AP, lateral views at 30° of knee flexion, as well as sunrise view, are valuable in detecting patella subluxation, osteochondral fractures, or dysplasia. The lateral radiograph in particular allows to evaluate the height of the patella and identify trochlear dysplasia. A "crossing sign" has been shown to be present in 96% of patients with history of true patella dislocation [71]. The classification of trochlear dysplasia has been described by Dejour based on the information provided by lateral and axial radiographs [71] (Fig. 19.8). MRI is a useful tool in assessing soft tissue, including the MPFL and cartilage surfaces. Following an acute episode of patellar instability, MRI usually shows bone marrow edema on the lateral femoral condyle and medial patella border [72]. Computed tomography (CT scan) allows bone assessment, especially trochlear dysplasia and shape of the patella. It may be used to quantify the lateralization of the tibial tuberosity, defined by the TT-TG distance [71]. A TT-TG distance greater than 20 mm is frequently associated with patella instability. The value of the TT-TG distance is taken into consideration in the preoperative planning of tibial tuberosity osteotomy.

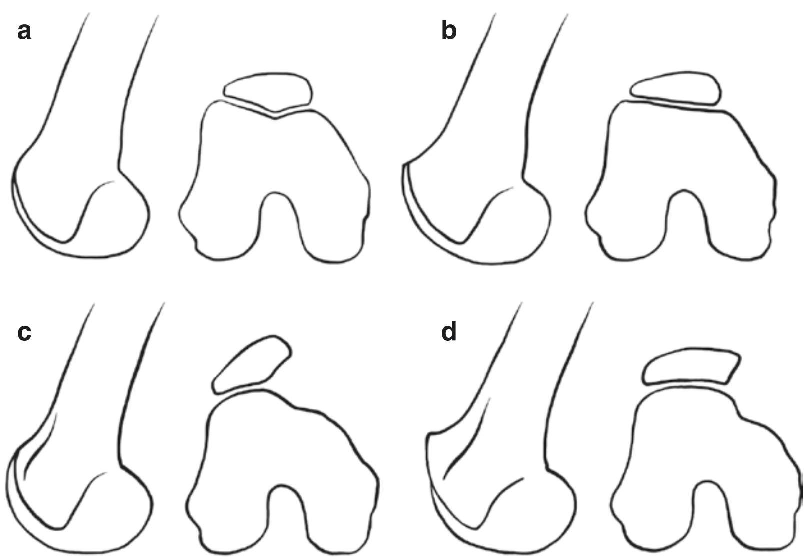

Fig. 19.8 Trochlear dysplasia classification of Dejour. Type A: Crossing sign, shallow trochlea >145°. Type B: Crossing sign, supratrochlear spur, flat or convex trochlea. Type C: Crossing sign, double contour (projection of medial hypoplastic facet). Type D: Crossing sign, supratrochlear spur, double contour, cliff sign

19.8.5 Treatment

Currently, there is no consensus concerning the management of a first traumatic patella dislocation [73]. The knee is usually immobilized in a brace after aspiration of the effusion, and early physiotherapy is recommended. Return to sport will depend on muscle recovery, patella control, and proprioception. Knee arthroscopy can be indicated in case of a displaced osteochondral fracture.

Different techniques have been proposed for the management of chronic instability, but there is still some lack of consensus in the literature [74]. MPFL reconstruction is currently the most popular surgical procedure. Tibial tubercle transfer procedures, including osteotomy of the tibial tubercle and medializing and/or distalizing its position (commonly a combination of both), can be used to correct increased TT-TG distance or patellar height issues. Trochleoplasty procedures can offer reshaping of the trochlear groove and may be considered in some selected cases of severe trochlea dysplasia. In the rare cases of abnormal rotational profiles of the lower limb (i.e., femoral anteversion; tibial external rotation), a de-rotational osteotomy may be considered. It is important to note that the effect of these procedures in handball players and their ability to return to sport has not been studied and is thus not known. The management algorithm of patellar instability in handball players should therefore be based on the risk factors, history of patellar instability, and level of sport [75]. Return to handball after surgical treatment depends on several factors including the importance of risk factors and type of surgical treatment. The delay is rarely less than 6 months. The percentage of patients capable to return to play has been reported to be higher than 90%; however the return to their pre-injury level of sport varies widely and is generally considered much lower (32–82%) [75].

Conclusion

Knee injuries, either acute or overuse injuries, are frequent in handball. Some of them are severe, like the ACL/PCL tears, some postero-lateral injuries, or quadriceps/patellar tendon ruptures where the time to return to play after treatment is usually more than 6 months. Meniscus tears should not be underestimated as their incorrect treatment can compromise a player's career. Any acute or overuse knee injury in handball must be accurately evaluated, using a cautious clinical examination and imaging, in order to provide the best treatment for return to sport to the same level.

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