Meniscus Ultrasound

15

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Contents

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15.1 Introduction

Since 2008 we have been applying ultrasound imaging in sport injuries and trauma of the knee joint.

We used handheld equipment and we progressively improved our skills. We therefore quickly enhanced the image quality.

A special dimension was acquired with the use of dynamic imaging, recording improved images. Our setup of direct feedback from the ultrasound with the feedback from arthroscopic images turned out to reduce the learning curve and gave the possibility of obtaining pictures that

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Table 15.1 Advantages/disadvantages of MSU/MRI

	MSU	MRI
Costs	Cheap	Expensive
Learning curve	Steep	Not applicable
Dynamic imaging	++	Only selected centers
Claustrophobia	Not applicable	5 %
Patient interaction	++	Not applicable
Therapeutic intervention	+ Possible	Seldom

had not been seen before by the companies selling the ultrasound equipment. Even up till this moment, very few colleagues consider ultrasound as an important imaging tool.

We think that ultrasound is a reliable tool to study the meniscus without the need to order a more expensive imaging, such as magnetic resonance imaging (MRI).

15.1.1 MRI Verses MSU

Advantages of musculoskeletal ultrasound (MSU) versus MRI are included in Table 15.1. Ultrasound has a steep learning curve, which needs to be overcome by increasing the number of patients analyzed and by interactive feedback.

We use ultrasound in the outpatient clinic during most of our consultation hours.

15.2 Imaging Assessment Meniscus

15.2.1 Radiographs

Degenerative arthritis and chondrocalcinosis are signs of possible meniscus degeneration.

Other lesions, like bone tumors, can be excluded.

15.2.2 Ultrasound

Diagnosis of ligament, meniscus, or cartilage lesions may be assessed with ultrasound imaging.

Dynamic ultrasound is indeed helpful in predicting reparability of lesions. In revision cases it is sometimes difficult to divide scars from fresh lesions. In these cases, dynamic imaging is extremely helpful to detect opening and closing of the meniscus tear. In this chapter all figures are orientated with the femur toward the left side and the tibia toward the right side. If another orientation is used, it is mentioned in the figure caption.

15.2.3 Probes

Ultrasound probes are very important for the overall system performance.

Nowadays most transducers use piezoelectric elements, which transmit, receive, and convert electrical signals and mechanical vibrations.

Improvement of the ultimate quality of ultrasound image depends on the type of probe, the number of piezoelectric elements, the quality of the ultrasound machine, and last but not least the experience of the ultrasonographer.

The probe frequency we use for meniscus ultrasound is mostly between 5 and 12 Mhz.

In the last 8 years we developed methods to visualize the cartilage, cruciate ligaments, and collateral ligaments, first with indirect signs and more recently by direct images. We started performing meniscus and knee ultrasound with smaller hand held equipment and we learned that better imaging could be achieved with stronger high-resolution equipment and special probes.

Dynamic imaging allows for:

- Movements during imaging.
- Displacements, which can be seen as a secondary sign of instability of the meniscus and ACL/PCL or other ligaments.
- Live feedback of the patient, who can sometimes produce a click or locking sensation while the ultrasound probe is on the joint space.
- Intra-articular injections in case of unclear symptoms.
- It can be helpful in patients with pes anserinus tendinitis to inject local anesthetics under ultrasound guidance under the pes tendon.
- With this diagnostic tool, painful tendinitis or scar tissue can be ruled out as a course of knee pain.

Figures 15.1, 15.2, and 15.3 show the improvement of images over the last 8 years.

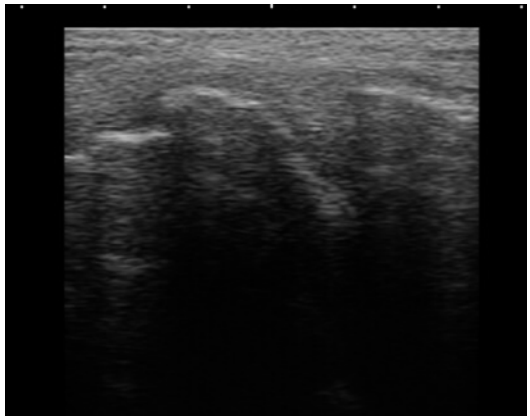


Fig. 15.1 Image meniscus 2006/2008, multifrequency linear probe with 64 piezoelectric elements. left femur, right tibia in prone position, the probe is vertical from the back of the knee

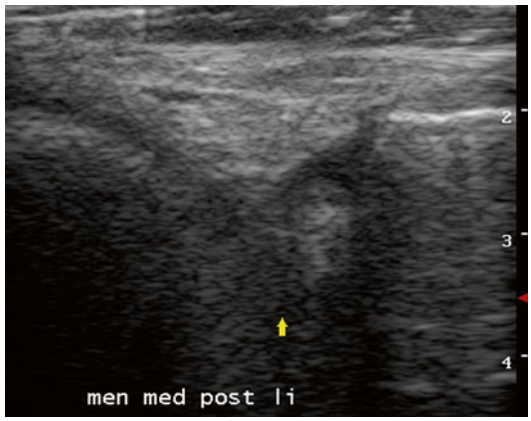


Fig. 15.2 Image meniscus 2008/2009, multifrequency linear probe with 128 piezoelectric elements

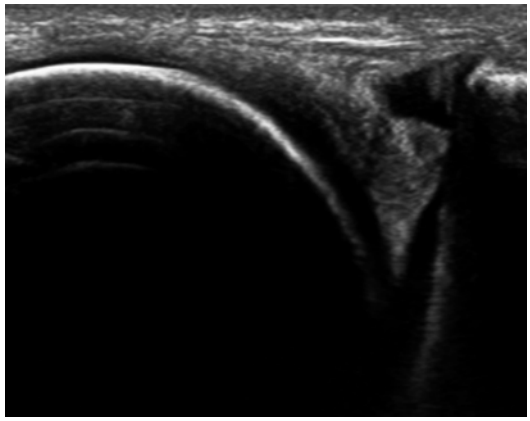


Fig. 15.3 Image meniscus 2015, broadband linear array high resolution probe 5-12 Mhz 256 piezoelectric elements, sonoCT

15.3 Knee Ultrasound Equipment and Setup

15.3.1 Meniscus Scanning Positions

Ultrasound imaging is performed in both supine position and prone positions, additional dynamic positions, stressing the medial or lateral compartments can be helpful. In prone position rotation can be applied to the foot in order to check for meniscus instability with cruciate ligament insufficiency (Fig. 15.4).

Supine with knee in flexion (Fig. 15.5) allows for scanning of the anterior and middle horn, cartilage conditions, and corpora (loose bodies); in full-flexion dynamic examination, ACL resistance or ACL elongation; and in prone position, PCL and posterior horn lesions. Dynamic prone, scanning with rotation of the foot, can show femorotibial subluxation with secondary meniscus opening or pulling forces (Video 15.1). The patient can sometimes feel and recognize the pain with movement of the meniscus posterior horn lesion.

Fig. 15.4 Meniscus ultrasound in prone position, checking posterior horns, PCL , cysts and vascular pathology

Special conditions, which can be better visualized with ultrasound, are fresh combined injuries of ACL and menisci, where excessive fluid can be a problem in MRI images. For instance, we found that avulsion fracture of the lateral tibia plateau (Segond lesions) is 5–10 times more frequently seen in ultrasound than in MRI [3, 5] (Video 15.2).

Fig. 15.5 Meniscus ultrasound of flexed knee (90 degrees)

15.4 History of Meniscus Ultrasound

In 1990 the first research by Jerosch [11] in Germany was published on ultrasound for the knee, showing that the use is limited to cysts, bursitis, and jumper's knee.

In 2002 an Italian study by Azzoni [2] concluded that ultrasound is not accurate enough for diagnosis of meniscus injury.

Since 2008 many reports have been published finding improved scores for sensitivity and specificity comparable with data for MRI [1, 6, 24, 27, 29].

At the same time MRI specificity seems to decrease with degeneration of the joint, showing that the risk of false-positive findings increases with aging.

15.5 Normal Meniscus

Meniscus vascularization is easily detectable by ultrasound. In the lateral meniscus a large vessel sometimes mimics pathology. In this case the vascular Doppler technology may be helpful (Fig. 15.6). The lateral recessus of the lateral meniscus needs to be localized, because it may resemble a meniscus rupture. The meniscus recessus gives a straight line. A meniscus tear shows a blurred line. A meniscus tear shows a blurred line (Fig 15.10 and 15.11)

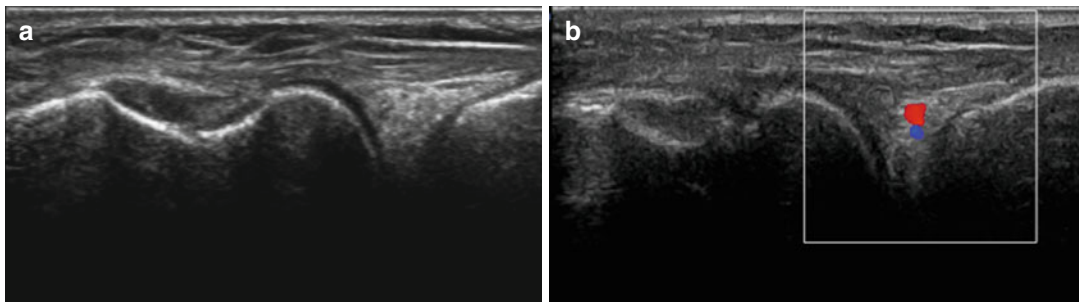


Fig. 15.6 (**a**) Anterolateral meniscus (**b**) Vascular Doppler technology

15.5.1 Lateral Meniscus Vascularization

Ultrasound of normal meniscus with location of vascularization (red zone) (Figs. 15.6 and 15.7)

The presence of a vessel between the lateral meniscus and the anterolateral capsule is a normal consistent finding. This also applies to the medial side. Thus, these ultrasound findings should not be considered pathological (Figs. 15.8 and 15.9).

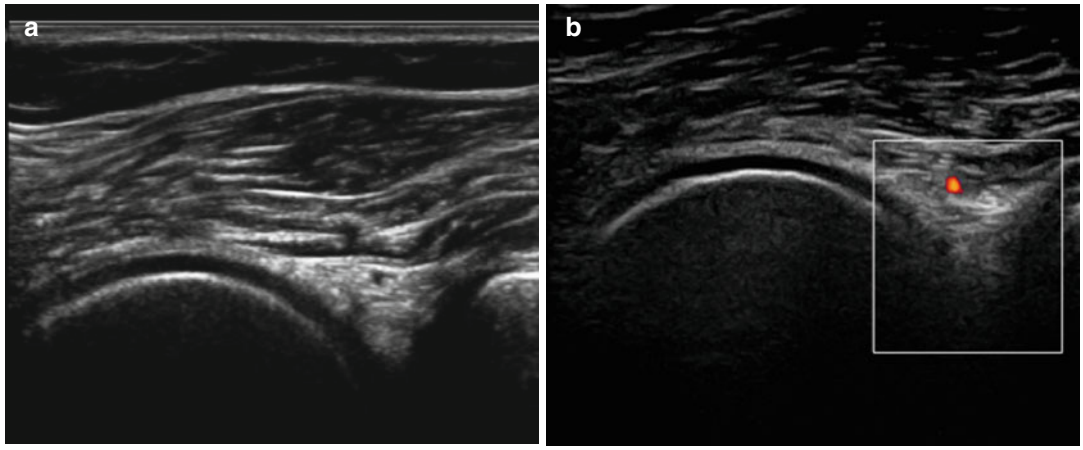


Fig. 15.7 (**a**) Posterolateral meniscus (**b**) Vascular Doppler technology

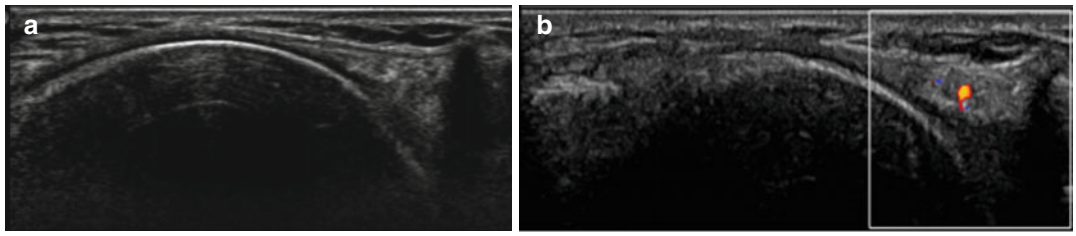


Fig. 15.8 (**a**) Anteromedial meniscus (**b**) Vascular Doppler technology

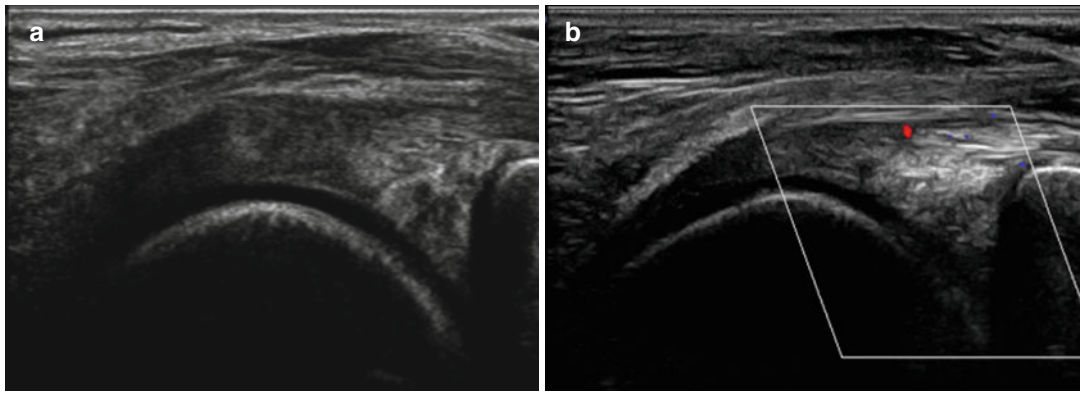


Fig. 15.9 (**a**) Posteromedial meniscus (**b**) Vascular Doppler technology

15.6 Conditions Suggesting Pathology

15.6.1 Lateral Posterior Popliteal Recessus

Normal lateral popliteal recessus meniscus lateral posterior (Fig. 15.10).

To be compared to a meniscus tear (Fig. 15.11).

15.7 Meniscus Pathology

15.7.1 Meniscus Tear

Several types of meniscus lesions can be detected by ultrasound. Direct visualization is nowadays possible in prone position (for the posterior part) if the meniscus is not dislocated. In case of a bucket-handle lesion, we can see a short posterior horn, where the front part is dislocated into the knee joint.

In the corner where the meniscus is twisted to a bucket handle, we can see a double meniscus, often rounded and surrounded by fluid (Figs. 15.12 and 15.13).

15.7.2 Meniscus Flap Tear

Some flap tears can be felt by the patient at the joint line and can be detected by ultrasound. A report on this finding was in presented by Moraux from France in 2008. With this imaging technique, the meniscus can be differentiated from a loose body, before surgery.

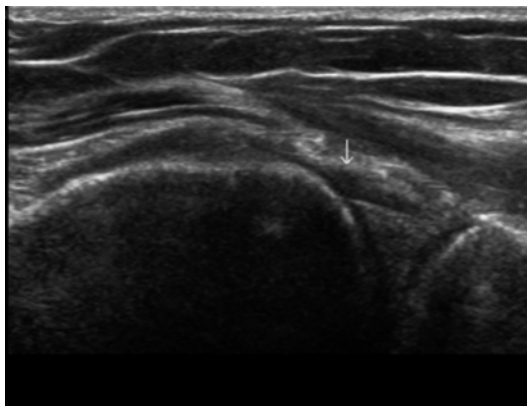


Fig. 15.10 Normal lateral popliteal recessus meniscus lat post

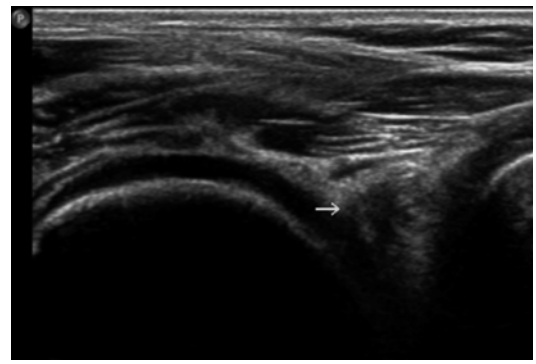


Fig. 15.11 Meniscus tear lateral meniscus

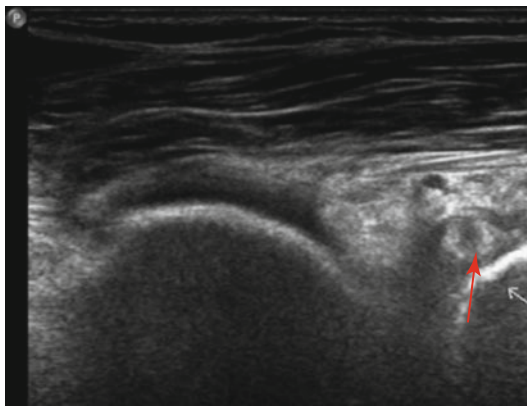


Fig. 15.12 Lateral meniscus posterior lesion with instable flap tear tibia site (see Fig. 15.13)

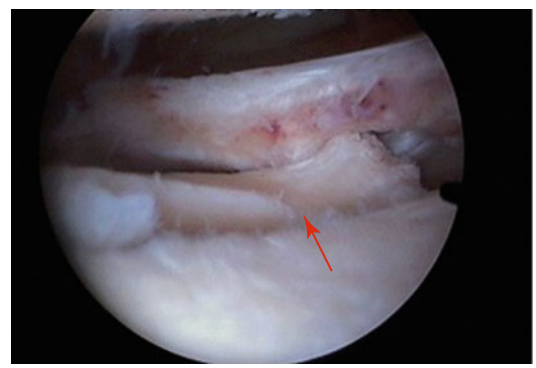


Fig. 15.13 Flap tear posterior lateral meniscus

15.7.3 Anterior Horn Dislocation of the Medial Meniscus

This condition (Fig. 15.14) is dynamically and clinically visualized in weight bearing.

Dynamic ultrasound used during weight bearing shows the anterior dislocation of the anterior horn of the medial meniscus [18, 21].

15.7.4 Meniscus Bucket Handle

The sign of a dislocated meniscus bucket-handle tear is a short meniscus (Fig. 15.15) with defect on the posterior aspect and double contours in the center and middle parts of the meniscus. Cartilage damage can be detected in recurrent and chronic cases (Video 15.3).

15.7.5 Hidden Lesions

We found some lesions more detectable by ultrasound than by MRI (Fig. 15.16 a–c).

Some specific lesions, called hidden lesions, which are located in the periphery of the posterior horn, are difficult to identify on MRI, but can be recognized in ultrasound images.

These lesions are described by Sonnery-Cottet and Neyret [20, 26].

In recent literature from MRI accuracy, it was obvious that especially lesions of the posterior horns of the meniscus can be missed on MRI studies [23].

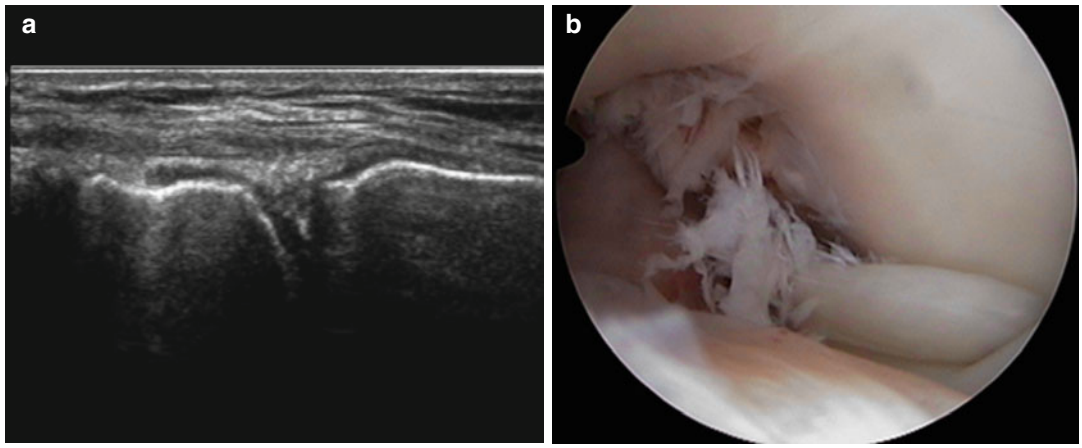
Figs. 15.14 Arthroscopic image meniscus anterior horn dislocation medial meniscus

15.8 Meniscus Combined Lesions

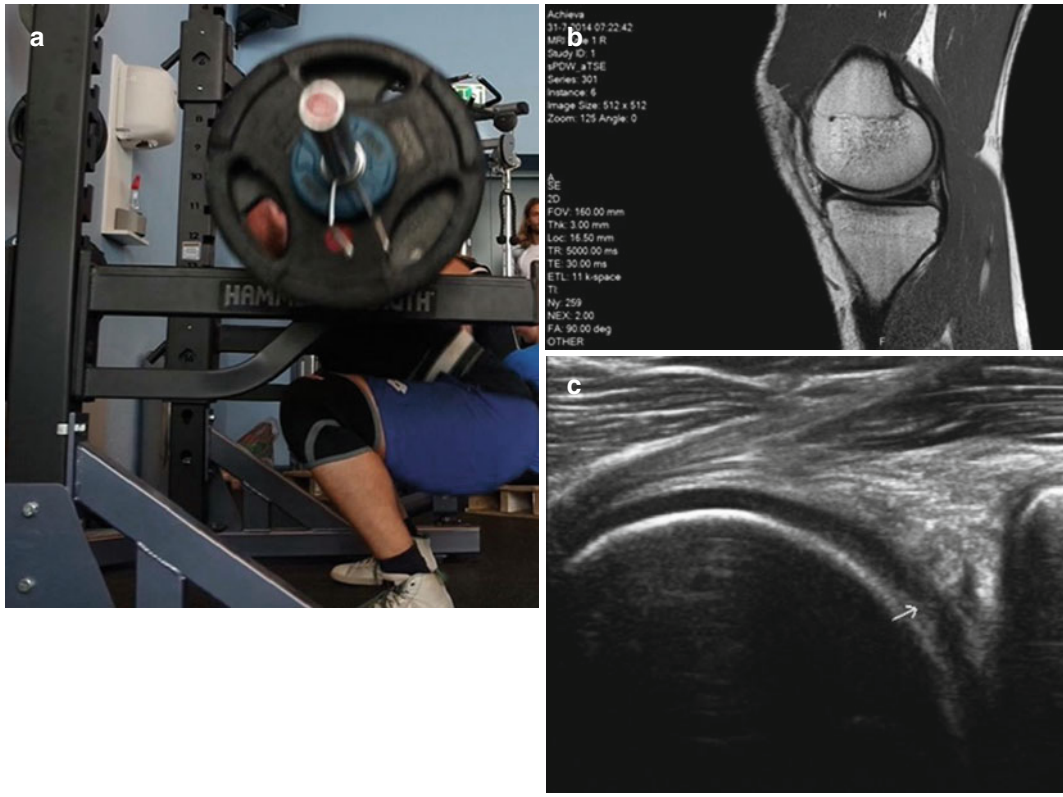
15.8.1 Meniscus and Anterior Cruciate Ligament Instability

In anterior cruciate ligament lesions, the pulling forces and rotation on the posterior parts of the meniscus increase. In prone position it is possible to rotate the knee in 40° of flexion.

In this position the displacement of the posterior medial plateau is visible in relation to the



Figs. 15.15 (**a**) Knee right medial posterior short meniscus (**b**) Arthroscopy image of dislocated medial bucket handle



Figs. 15.16 In this patient 24-year old powerlifter (**a**) the meniscus lesion was not found on MRI (**b**) but seen on dynamic high resolution ultrasound (**c**)

medial femur condyle and the pulling forces opening and closing the posterior part of the medial meniscus (Figs. 15.17, 15.18, and 15.19) (Video 15.1)

15.8.2 Meniscus Follow-Up in ACL-Deficient Knees

In conservative treatment of ACL lesions, the knee kinematics can be analyzed with sequential ultrasound examination to check the force on the posterior horn of the menisci. When a sign of imminent meniscus rupture is present, reconstruction of the ACL is mandatory. This can prevent secondary damage in an ACL-deficient knee. In these cases, the patient can be more easily followed with ultrasound than with MRI [30].

15.9 Meniscus Repair

15.9.1 Ultrasound for Meniscal Repair

We perform repair of meniscus ruptures in:

- Patients under 35 years of age, with reparable lesions and no degeneration (MRI/ultrasound).
- Patients over 35 with total meniscal dislocation especially in ACL cases.
- Hypermobile meniscus with recurrent locking.

Meniscus (re)rupture can occur without obvious trauma or with squatting.

Most patients describe flexion and or rotation from the injured knee while twisting the knee.

Fig. 15.17 Meniscus ultrasound rotation in prone position

The knee is usually painful in acute ruptures, but severe variety is recorded in symptoms.

Examination assesses the amount of swelling and location of pain. Swelling is variable and can limit the range of motion. Extension is usually limited in locked dislocation but can be hard to distinguish with acute swelling.

Dynamic ultrasound is able to detect dislocation and repairability of the meniscus (Video 15.3).

Power Doppler imaging can be performed to check for the vascularization of the meniscus, as most of the surgeons prefer to repair meniscus lesions in the vascularized zone.

Some specific vessels, for instance, a normal feeding vessel, can be detected between the lateral meniscus and the collateral ligaments (Fig. 15.16).

15.9.2 Meniscus Spontaneous Healing

When the meniscus tear is located in a peripheral vascularized part of the meniscus, spontaneous healing can be monitored (Fig. 15.20). If the patient is recording persistent symptoms, a meniscus repair can be scheduled. If the lesion is combined with an ACL deficiency, a combined procedure is advised.

In some cases of conservative treatment of an ACL rupture, we recorded persistent pain on the

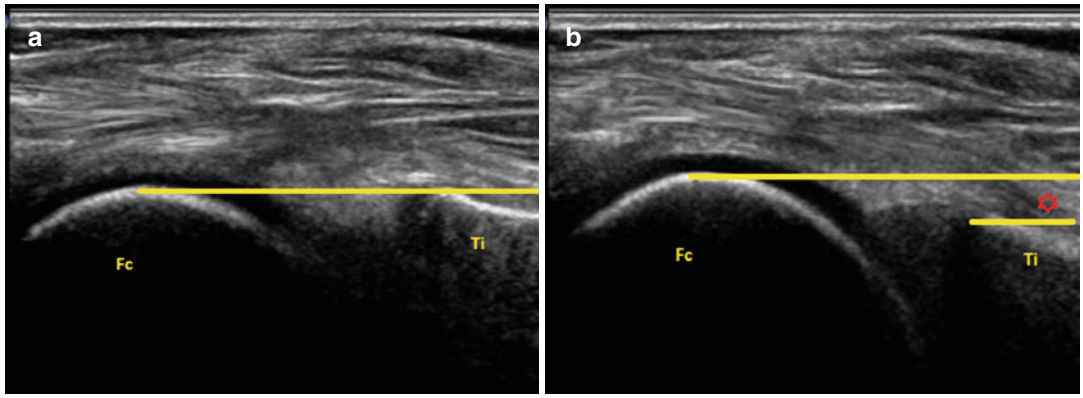


Fig. 15.18 Unaffected side

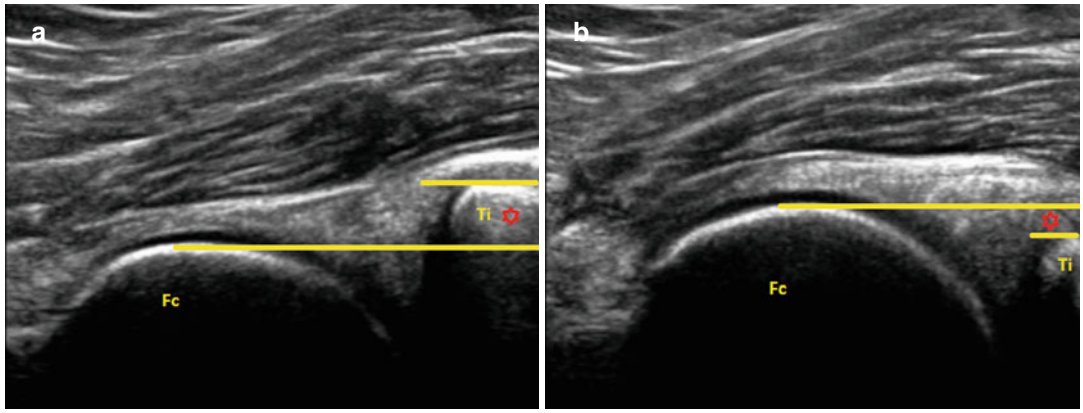


Fig. 15.19 Affected side (instability)

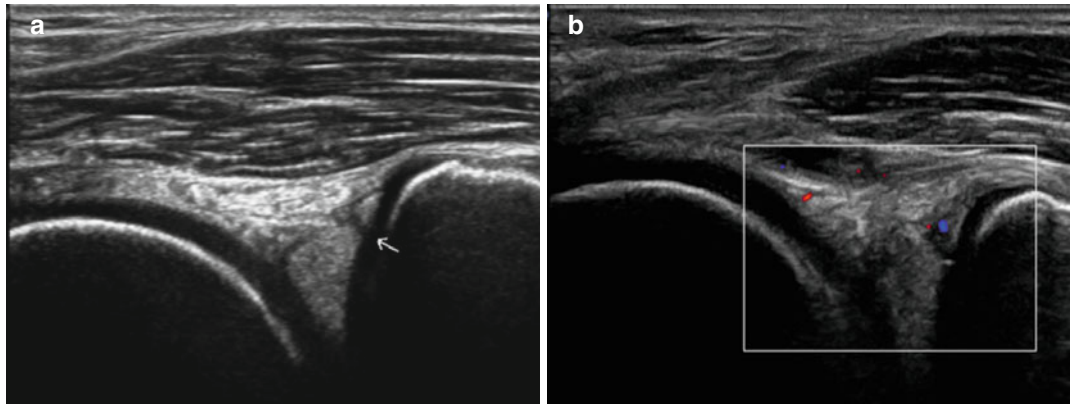


Fig. 15.20 (**a**) Peripheral Medial Meniscal lesion (**b**) Vascular Doppler technology

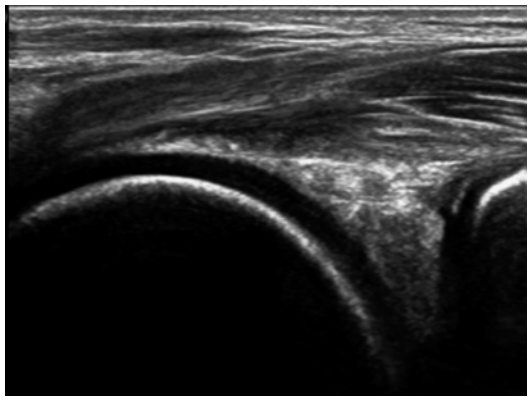


Fig. 15.21 Spontaneous healing 1 month post trauma

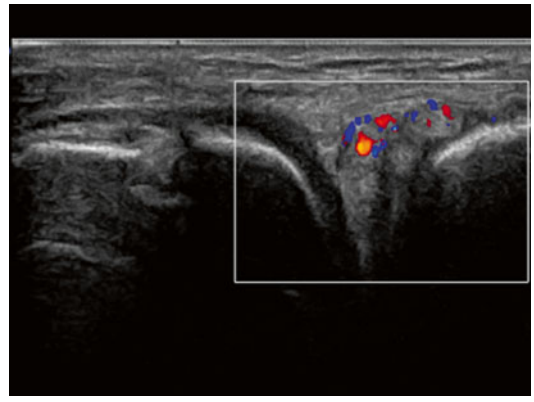


Fig. 15.22 Ultrasound powerdoppler vascularisation posterior horn in healing meniscus

joint space. We found meniscus lesions in these patients even before a rupture could be found with arthroscopy. These lesions have a good prognosis after ACL reconstruction (Fig. 15.21). Trephination of the meniscus in this condition is an option to promote vascularization.

15.9.3 Meniscus Reparability

Peripheral tears can have a good healing capacity, especially if they occur in the vascularization zone.

Ultrasound imaging can monitor healing and help with making a decision for surgery in case of prolonged symptoms (Fig. 15.22) (Video 15.4).

15.9.4 Meniscus Repair

Ultrasound is also used to follow up meniscus healing after repair. We can see small cysts around meniscal implants to impair the healing. Dynamic imaging is used to check the stability of the healing meniscus (Fig. 15.23) (Video 15.5).

Rehabilitation protocols can be adjusted according to the findings in meniscus healing with ultrasound.

Neovascularization with small vessel ingrowth in the red white zone can be seen in the first months after meniscus repair.

15.9.5 Acute Lesions

Fresh lesions of the meniscus are often seen in combination with ligament injuries.

We check for both intra- and extra-articular ligament lesions. It's particularly important to look for avulsion fractures like Segond lesion and medial collateral ligament in acute combined lesions. Impression of the lateral femoral condyle

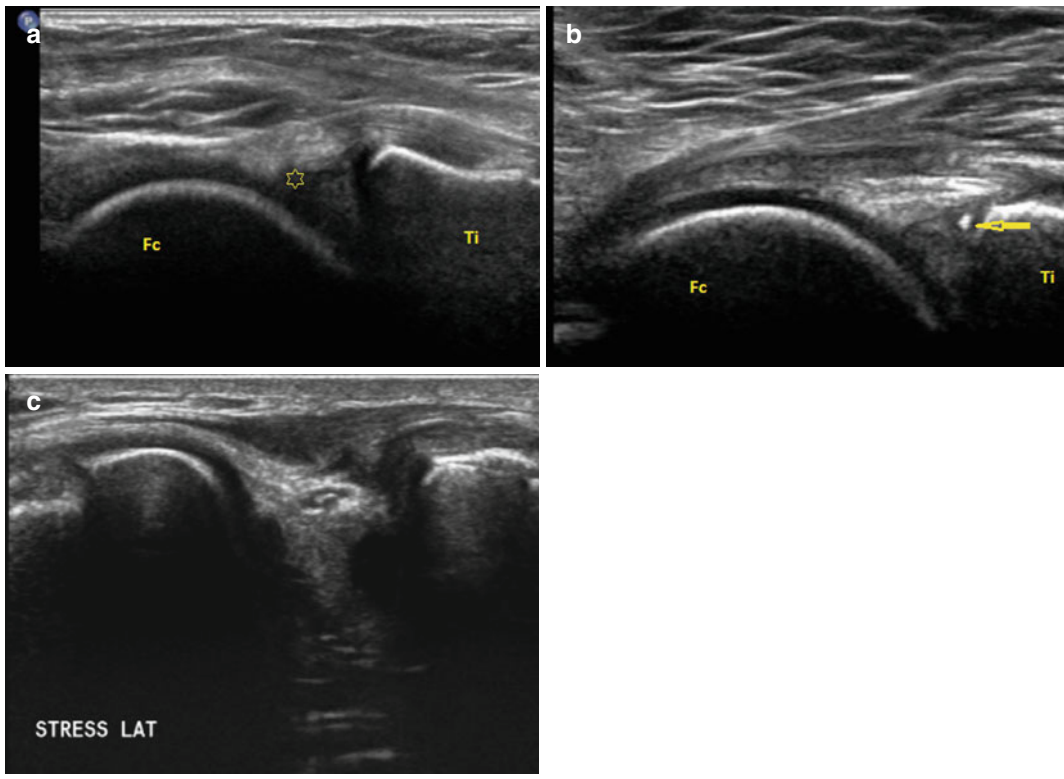


Fig. 15.23 (**a**) Preoperative meniscal lesion medial posterior (**b**) Meniscus repair 1 month post-operative (**c**) Meniscus repair six months post-operative

is seen in high-velocity trauma and is often associated with lateral meniscus rupture [9].

In acute lesions massive fluid in the joint can cause artifacts in the imaging.

To our opinion the acute hematoma is less problematic in ultrasound and sometimes helpful to detect fresh versus old lesions. The example of Segond lesion in acute knees is supporting our finding that ultrasound can be more powerful to detect acute lesions than MRI. This is due to the fluid and hematoma but also due to the possibility to quickly orientate in multiple directions with an ultrasound probe. In the detection of Segond lesions, MSU (Fig. 15.24) can be more reliable than MRI and X-ray [13]. (Videos 15.2) (Table 15.2).

15.10 Specific Conditions

15.10.1 Meniscus Degeneration

Degeneration can be a sign of aging of the meniscus, but it is also seen in cases of long-standing ACL deficiency as a sign of overloading of the meniscus.

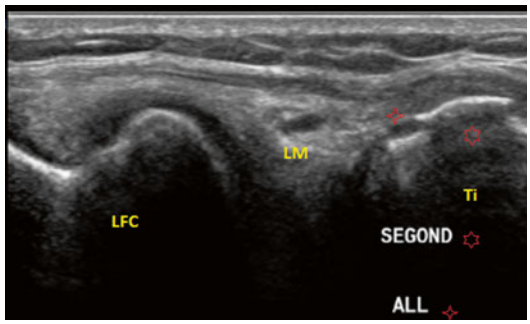


Fig. 15.24 Ultrasound detection of an acute Segond lesion in combined knee injury

Table 15.2 Incidence of Segond lesions in imaging modalities

	Incidence in ACL rupture	
X-ray	9 %	Klos [13]
MRI	3–6 %	Claes [5], Bock [3]
Ultrasound	33 %	Klos [13]

15.10.2 Meniscus Chondrocalcinosis

A meniscus with calcification can be detected in a normal knee X-ray; most frequently both joint spaces are involved.

A meniscus with hardening is more susceptible to injury and tearing, and if mechanical symptoms are persistent, a question for preoperative imaging can be a problem. This condition is usually found in the elderly age groups and the combination of aging and chondrocalcinosis makes MRI imaging more complicated. In the use of ultrasound, fluid around the posterior parts of the meniscus, and cyst formation can be indirect signs of a persistent meniscus mechanical problem (Figs. 15.25 and 15.26).

Fig. 15.25 Chondrocalcinosis on ultrasound

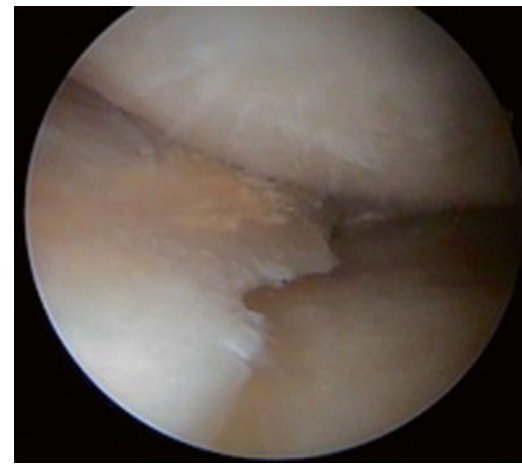


Fig. 15.26 Chondrocalcinosis intra-operative medial meniscus

15.10.3 Meniscus Extrusion

Meniscus extrusion is seen as an indirect sign of meniscus pathology. This sign is indeed described both with MSU and MRI in several papers. Meniscus extrusion is seen both in meniscal degeneration and in other pathological conditions of the meniscus; as the meniscus loses its hydraulic power in both these affections. A meniscal displacement of more than 3 mm is considered abnormal on the medial site, while a displacement above 4 mm is abnormal on the lateral site [28]. A recent study from Noguira-Barbosa confirmed the reliability of ultrasound [17]. Nguyen [16] found both meniscus extrusion and parameniscal cyst formation as sign of meniscal lesion (Fig. 15.27).

15.10.4 Meniscus Cyst

Ultrasound is helpful not only to detect the cysts but also to check for:

- Underlying meniscus pathology (lateral meniscus cyst) [10, 22, 25].
- Primary or secondary cyst formation.
- The size of the cyst walls. If there are signs of a thickening cyst wall, resection of the wall by an open approach can be considered.
- Puncture of the cyst and injection can be considered in patients without the possibility for operative treatment.

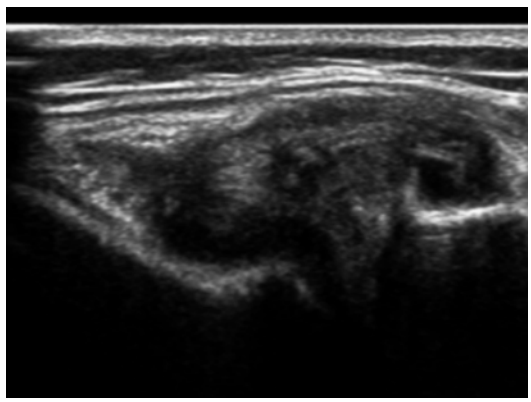


Fig. 15.27 Large meniscus cyst

In case of meniscal tearing, the cyst is directly connected with the tear (Figs. 15.28 and 15.29).

In case of a Baker's cyst, there is usually fluid in the knee joint, which fills the Baker's cyst as a consequence.

15.10.5 Discoid Meniscus

Since ultrasound is used to check dynamic pathology, it is possible to detect instable lesions in discoid meniscus by moving the knee in figure of 4 position with the probe on the lateral

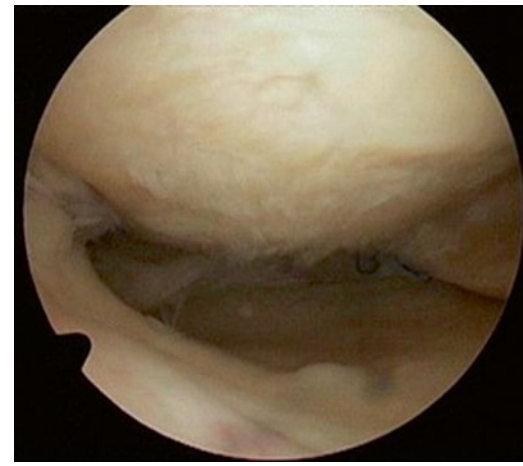


Fig. 15.28 Intra-operative arthroscopic image medial meniscus and condyle

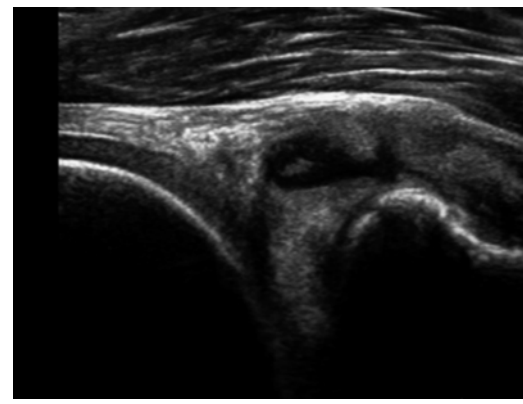


Fig. 15.29 Ultrasound parameniscal cyst with medial meniscus lesion and chondropathy

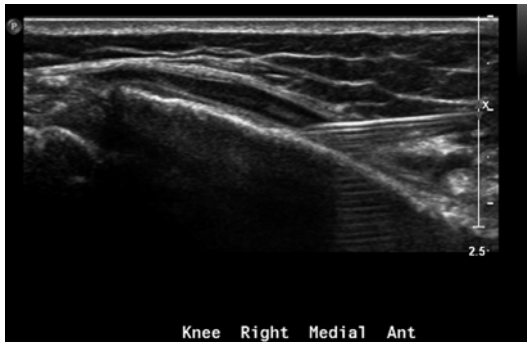


Fig. 15.30 Ultrasound guided injection bursa under the pes anserinus, on the right above needle is injecting corticosteroid to the front of the anteromedial tibia

joint space. Recently Jose and his group published on the possibilities of diagnosis with dynamic ultrasonography [12].

15.11 Complications or Prolonged Symptoms After Surgery

Ultrasound can be used to detect migration of meniscus implants [8].

In particular, vascular complications can be detected with ultrasound; reports of pseudoaneurysm and cysts around meniscus implants are found [4].

Ultrasound is the gold standard technique to diagnose postsurgical thrombosis.

Routine follow-up ultrasound after ACL reconstruction shows 12 % of thrombotic events [7].

In case of prolonged pain or swelling, we use ultrasound to detect bursa or tendinitis around the pes anserinus. Pain release was obtained after injection with lidocaine and/or corticosteroids (Fig. 15.30).

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