EURO-MUSCULUS/USPRM Dynamic Ultrasound Protocols for Knee

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This feature is a unique combination of text (voice) and video that more clearly presents and explains procedures in musculoskeletal medicine. These videos will be available on the journal's Website. We hope that this feature will change and enhance the learning experience.

Walter R. Frontera, MD, PhD
Editor-in-Chief

Abstract: In this dynamic scanning protocol, ultrasound examination of the knee is described using various maneuvers to assess different conditions. Real-time patient examination and scanning videos are used for better simulation of the daily clinical practice. The protocol is prepared by several/international experts in the field of musculoskeletal ultrasound and within the umbrella of European Musculoskeletal Ultrasound Study Group in Physical and Rehabilitation Medicine/ Ultrasound Study Group of the International Society of Physical and Rehabilitation Medicine.

Key Words: Ultrasonography, Knee, Examination, Maneuver, Physiatry

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Ultrasound (US) examination of the knee has already become routine in the daily clinical practice of physiatrists. Although dynamic evaluation is an absolute/added value in knee examination, a comprehensive approach for knee pathologies does not exist in the literature. Accordingly, as the extension of basic scanning,[1] an international group of experts elaborated this scanning protocol for dynamic US examination of the knee.

ANTERIOR VIEW

Relevant anatomic structures in the suprapatellar and infrapatellar regions that are amenable to dynamic US examination are the quadriceps tendon, suprapatellar synovial recess, suprapatellar fat pad, prefemoral fat, distal femoral metaphysis, the trochlea, patellar tendon, Hoffa's fat pad, peripatellar bursae, and the anterior cruciate ligament.

Technique

Scanning starts in the neutral position, that is, the patient lying supine on the examination bed with the knee in mild flexion (20–30 degrees)—possibly supported with a pillow under the popliteal fossa. Different angles of knee flexion/extension and patient positioning can easily be performed during the examination. The probe is placed anteriorly in the suprapatellar, juxtapatellar, and infrapatellar regions to assess several bony structures and surrounding soft tissues (e.g., tendons, recesses, entheses). As elsewhere, short- and long-axis imaging is done while bony prominences serve as anatomical landmarks for prompt orientation.

Clinical Indications

Suprapatellar Extensor Pathologies

While sitting on the examination bed and the ankle/foot hanging outside, long-axis imaging over the quadriceps tendon can be performed during active/passive knee movements. Contraction of the quadriceps muscle and gliding of its tendon can be evaluated for different injuries. For instance, a tear in the quadriceps tendon might become (more) evident with passive stretching or isometric contraction, that is, "opening the gap" (Videos 1, 2, and 3, http://links.lww.com/PHM/B907, http://links.lww.com/PHM/B908, and http://links.lww.com/PHM/B909). Moreover, this maneuver can be useful also to evaluate an eventual bony avulsion of the superior pole of the patella (stable or unstable).

Impingement and Intraarticular Loose Body

After evaluating the femoral trochlea and the overlying cartilage in maximum flexion, a mechanical conflict that blocks/impedes the knee extension (i.e., bony spur, hypertrophic synovium, loose body) can be observed during active/passive movements. In case of a loose body (e.g., cartilage/bone fragment or calcium deposit), especially the suprapatellar recess needs to be thoroughly scanned for other "floating objects."[2]

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Effusion/Synovitis/Fat Edema

Similar to other joint examinations, the presence of intraarticular fluid is usually the initial parameter to be assessed in the knee. Herein, as the knee joint is quite superficial, caution as to not apply unnecessary compression with the probe is paramount. Likewise, it is also important to recall which position of the joint facilitates fluid accumulation in which compartment. While flexion will separate the layers of the suprapatellar recess that will lodge the fluid, extension will commonly push it toward the lateral recesses.[1,3,4]

The normal synovium is thin and hardly detected upon US imaging. Herewith, synovitis is seen as irregularly thickened, hypoechoic, nondisplaceable, and poorly compressible tissue in a great spectrum of inflammatory conditions. As such, in addition to joint movements, probe or manual compressions (to aid accumulation) would also be contributory.

Peripatellar fat pads are intracapsular extrasynovial adipose cushions that accommodate the changing shape.[5] Dynamic scanning with joint/probe movements also allows for better visualization by mobilizing the fluid/edema content (Videos 4 and 5, http://links.lww.com/PHM/B910 and http://links.lww.com/PHM/B911). Moreover, dynamic scanning can also be used to visualize a snapping or an abnormal displacement of the fat pads of the knee.[6]

Anterior Cruciate Ligament

Having oblique trajectory and deeper location, the ligament is considered to be a challenging structure for US imaging.[7–10] In practice, it can be evaluated statically and dynamically, that is, during anterior drawer test[11] (Fig. 1). The distal stump can be observed freely mobile (Video 6, http://links.lww.com/PHM/B912) during the (increased) anterior translation of the tibia.[12]

Patellar Tendinopathy (Jumper's Knee)

Commonly due to overuse activities, for example, running and jumping, chronic microtrauma to the tendon is the main underlying mechanism.[13] Although static US scanning provides high-resolution/quality images, the sensitivity/specificity of the examination can notably be furthered with dynamic assessment (Fig. 2). Addition of sono-palpation or stretching would be of great help for better localization of the (minor) lesion or

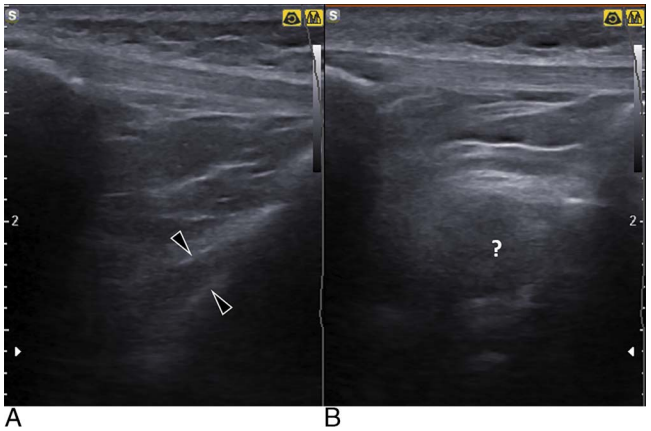

FIGURE 1. Long-axis imaging of (A) healthy (arrowheads) and (B) ruptured (?) anterior cruciate ligaments.

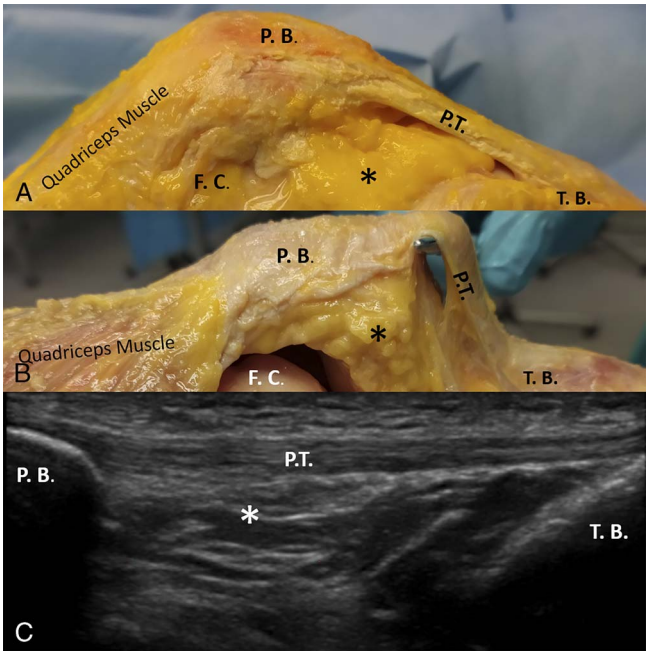

FIGURE 2. (A, B) Cadaveric dissection and long-axis imaging (C) shows the patellar tendon and Hoffa fat pad. P indicates patella; FC, femoral condyle; T, tibia; *, Hoffa fat pad.

understanding the real-life complaint of the subject (Video 7, http://links.lww.com/PHM/B913). Moreover, this maneuver can also be useful to evaluate an eventual bony avulsion of the inferior pole of the patella (stable or unstable).

Hoffitis

The Hoffa's fat pad is interposed between the trochlear articular surface and the superior tibia posteriorly and patellar ligament anteriorly[5] (Fig. 2). Sustained friction and repetitive microtrauma can lead to the clinical manifestation whereby pain is commonly exacerbated by hyperextension.[14] Likewise, dynamic US examination during knee extension can reveal the fat pad edema and/or impingement.[15] In addition, the origin of certain cystic lesions within the fat pad (i.e., intraarticular) can be confirmed—possibly related to the anterior cruciate ligament—with mobilization of the ligament.

Osgood-Schlatter and Sinding-Larsen-Johansson Syndromes

These two syndromes represent traction enthesopathy on either side of the patellar tendon attachments.[16] Reactive secondary heterotopic bone formation, resulting in a visible and palpable lump on the enthesis, is the main clinical finding. Thickening of the patellar tendon with low-reflective changes and associated intratendinous calcifications can be seen during US examination where dynamic imaging can also reveal stiffness and reduction of movement in the tendon. Findings pertaining to cartilage swelling/fragmentation and bursitis (Videos 8 and 9, http://links.lww.com/PHM/B914 and http://links.lww.com/PHM/B915) can accompany the scenario as well.[17,18]

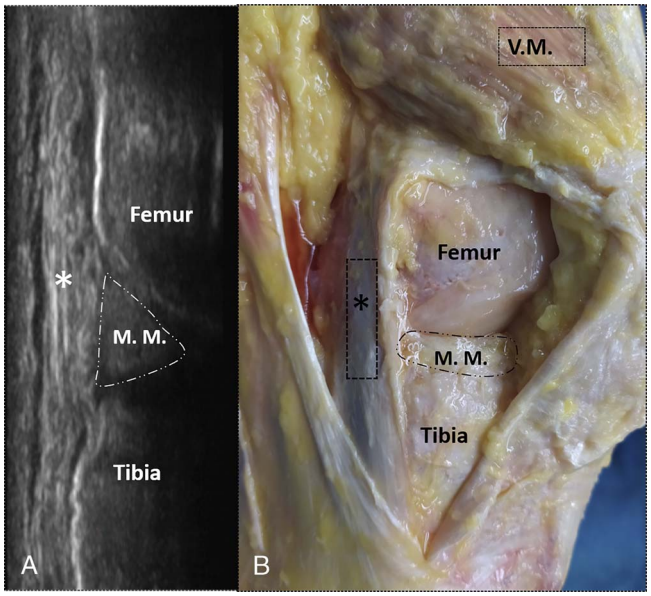

FIGURE 3. (A) Long-axis imaging and (B) cadaveric dissection shows the anatomical location of medial collateral ligament (*) and medial meniscus (MM). VM indicates vastus medialis muscle.

Bursitis

Several peripatellar bursae can be involved either secondary to concomitant knee joint disorders or as the primary pathology, for example, Housemaid's knee. The underlying cause is commonly overuse and the typical finding is fluid accumulation.[18] Therefore, the aforementioned technical tips for joint fluid and synovitis would also be valid for the examination/diagnosis of bursitis.

MEDIAL VIEW

The medial aspect of the knee joint is examined with the leg externally rotated. Relevant anatomic structures in this area that are amenable to US examination are the medial collateral ligament, medial femorotibial joint space, medial meniscus, and the pes anserinus complex.

Technique

Dynamic US imaging with valgus stress can improve the assessment for integrity of the above-quoted anatomical structures. For this purpose, the patient is asked to lean on the same side, with slight knee flexion. After coronal images are obtained at rest, either a small stiff pillow is placed under the lateral aspect of the knee or external manipulation is applied to produce valgus stress. Widening of the medial joint space can increase the overall visibility of structures whereby flexion/extension might better show reciprocal relations between femur, menisci, ligaments and tibia.

Clinical Indications

Medial Collateral Ligament Injury

Commonly in different sports players, overuse injuries of the medial collateral ligament can ensue and cause joint instability.[19] Involvement of the meniscofemoral ligament is more frequent and dynamic examination under valgus stress would be noteworthy, especially for partial-thickness tears. Further detailed examination of this area can be done as described previously, also/especially the histological junction between the medial meniscus and the meniscofemoral or meniscotibial ligament after trauma.[20] While a reproducible anechoic gap is the hallmark for tears, attachment site calcifications might also develop (i.e., Pellegrini-Stieda syndrome) and hamper the movement during valgus stress.

Similar to other sites, bursitis between the superficial and deep fibers of the meniscotibial ligament (Video 10, http://links.lww.com/PHM/B916) can be observed (i.e., bursitis of Voshell).[21,22] Assessing the real-time interactions between fluid and fibrous components (Video 11, http://links.lww.com/PHM/B917) can be contributory to better ascertain the diagnosis and treatment.[23]

Medial Meniscopathy

The medial meniscus can be visualized in coronal and coronal oblique views by placing the probe perpendicular to its (superficially located) base (Fig. 3). Again, widening the medial joint space by valgus stress increases the visibility for better evaluating its stability. Moreover, extrusion—defined as the extension of meniscus beyond the medial edge of the tibiofemoral joint[24]—can even be examined/measured in lying and standing positions. Previous studies have demonstrated that extrusion increases with weight-bearing in both healthy and arthritic knees.[25–28] By adding maneuvers (e.g., flexion/extension, valgus/varus stress), dynamic US assessment can further help to better evaluate mobility of the medial meniscus to highlight microinstability or macroinstability and/or extrusion. In extreme conditions (e.g., snapping, locking), understanding the exact mechanism would, for sure, guide the management as well (Videos 12, 13, and 14, http://links.lww.com/PHM/B918, http://links.lww.com/PHM/B919, and http://links.lww.com/PHM/B920). In some patients, during the dynamic maneuver, a subluxation or luxation of the medial meniscus can be visualized slipping under the superficial fibers of the medial collateral ligament.[29] Another interesting "indirect" sonographic sign of medial meniscus instability is the dynamic bulging of superior/inferior para-meniscal recesses during the dynamic assessment. Indeed, articular effusion flows inside the aforementioned recesses during the valgus stress in patients with instability of the medial compartment of the knee.[29]

Pes Anserine Pathologies

The pes anserine complex is composed by the intermingling tendons of the sartorius, gracilis, and semitendinosus muscles. It inserts into the anteromedial aspect of the tibial metaphysis,

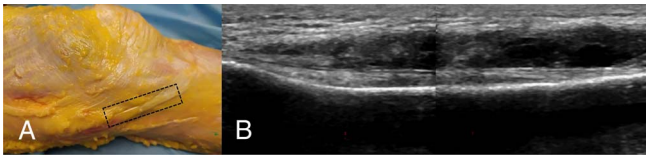

FIGURE 4. (A) Cadaveric dissection shows the anatomical location of pes anserine tendons. (B) Long-axis imaging shows the pes anserine complex (tendons and bursa) in a scenario of bursitis.

5–6 cm below the joint line[19] (Fig. 4). Although difficult, individual tendons can be distinguished with their shapes/locations and flexion/extension movements.

Snapping pes anserine tendons are the main cause of extra-articular knee snapping.[30] During dynamic assessment with repetitive flexion/extension of the knee, snapping of the pes anserine tendons can be visible (as well as audible).[31] The examiner must take care to keep the transducer anchored on the anatomical structures in question while performing relevant/dynamic maneuvers.

Tendinitis/bursitis of the pes anserine region or ganglion cysts can be observed in various patients, for example, rheumatoid arthritis and diabetes mellitus.[32] Like elsewhere, while sono-palpation can help to localize/differentiate the exact cause, passive/active movements might help to confirm structural lesions.

Medial Retinaculum or Patello-Femoral Ligament Problems

Dynamic US scanning from the medial patellar window can improve the assessment of medial ligamentous complex integrity. As the patient lies supine, the examiner can mobilize the patella in the lateral direction. This way, complete/partial avulsion of these structures from the patella, for example, torn edges or gap filled with fat, might become more evident.[33,34]

LATERAL VIEW

Technique

The lateral aspect of the knee joint is best examined by asking the patient to rotate the leg internally. From anterior to posterior, the structures to be evaluated are the distal aspect of the iliotibial band, the external femorotibial joint space with the lateral meniscus, the lateral collateral ligament, the popliteus tendon, and the distal biceps femoris tendon. Imaging the peroneal nerve is also commonplace in daily practice. The patient is asked to lean on the contralateral side of the examined knee, maintained in slight flexion. Then, a small stiff pillow is placed under the medial aspect of the knee to produce varus stress with the weight of the leg. For sure, varus stress can also be produced with manual compressions, and extra active/passive movements can help to better visualize the different anatomical structures simulating daily life.

Clinical Indications

Iliotibial Band Syndrome (Runner's Knee)

Iliotibial band (friction) syndrome is an overuse disorder of the lateral knee. It is commonly reported in athletes, such as runners and cyclists, and refers to local pain related to physical activity.[35] The friction against the lateral condyle is more apparent at 30 degrees flexion of the knee. As such, dynamic US examination can uncover the precise mechanical conflict during joint movements—especially when combined with sono-palpation and the clinical findings. Of note, the presence of a bursa in between can also be observed during mobilization of the joint/probe (Videos 15 and 16, http://links.lww.com/PHM/B921 and http://links.lww.com/PHM/B922).

Lateral Collateral Ligament Injury

This ligament is the primary stabilizer with regard to varus instability of the knee.[36] Similar to the medial side, long-axis imaging with varus stress can easily be applied. Considering the difficulty of (otherwise static) imaging for this ligament, especially in partial tears, such a maneuver might significantly facilitate the imaging of an anechoic gap between the fibers of the ligament or between the ligament and its insertions. Again, insertional lesions can be accompanied by bony avulsions and overt lesions might cause joint instability whereby both scenarios can be explored under US (Videos 17, 18, and 19, http://links.lww.com/PHM/B923, http://links.lww.com/PHM/B924, and http://links.lww.com/PHM/B925).

Lateral Meniscopathy

Peripheral (vascular) zone problems of the meniscus (e.g., radial tear, instability) can dynamically be tested. The painful catch-up clunk, most commonly present with active flexion/extension knee movements, can indicate translocation of the lateral meniscus or associated meniscal cyst.[37]

Lateral Retinaculum or Patello-Femoral Ligament Problems

Similar to the medial complex, the examiner can mobilize the patella toward the opposite direction, trying to cause patellar dislocation. Likewise, the probe can also be used to apply mechanical stress while the integrity of the lateral complex can be assessed.[38,39] For sure, the physician is free to test extra maneuvers in light of the clinical/physical examination findings.

Snapping Biceps or Popliteus Tendons

During flexion/extension of the knee joint and depending on the probe localization, snapping biceps femoris or popliteus tendons can be visualized over the fibular head or along the popliteal groove, respectively.[40–43] Needless to say, in case of snapping, relevant structures can also display findings of overuse, for example, edema, partial tear and swollen bursa (Video 20, http://links.lww.com/PHM/B926).

Peroneal Neuropathy/Entrapment

Whereas static imaging can show several forms/reasons of peroneal nerve entrapment around the fibula, dynamic examination might provide additional information using sono-Tinel and knee movements (Video 21, http://links.lww.com/PHM/B927), especially in the presence of nerve dislocation (because of space-occupying lesions, fractures, osteophytes, and fibular deformities.[44]

POSTERIOR VIEW

The posterior aspect of the knee joint is examined by asking the patient to settle in prone position. The structures to be evaluated are semimembranosus-gastrocnemius bursa, popliteal neurovascular structures, and the posterior cruciate ligament. Active flexion/extension movements can help to better visualize the different anatomical structures. Moreover, the examiner can study the stability of these structures with the help of counter-resistance (maneuvers).

Baker (Popliteal) Cyst

While evaluating the popliteal fossa, it is important to examine the semimembranosus-gastrocnemius bursa from which Baker cysts originate. They generally communicate with the joint space through a thin neck and a valvular opening, which allows flow during knee flexion but (because of the tension between the aforementioned muscles) not during extension.[45] Accordingly, dynamic US assessment may help to visualize this "fluid behavior," as well as its content. In addition, in case of ruptured cysts, fluid may be seen tracking inferiorly in the calf (gastrocnemius-soleus complex), possibly causing a painful scenario also known as pseudothrombophlebitis (Video 22, http://links.lww.com/PHM/B928).

Popliteal Artery Entrapment Syndrome

This clinical condition refers to compression of the popliteal artery secondary to its relationship with abnormal proximal insertion of the medial gastrocnemius or popliteus muscles. It is a rare condition, with higher prevalence in young healthy males, whereby the symptomatology consists of vascular insufficiency in the absence of any atherosclerotic disease. Initially, it can be asymptomatic but later on might cause calf claudication and loss of arterial pulses during ankle motions.[46] Dynamic US and Doppler scanning might really be contributory if performed during ankle plantar/dorsiflexion.

Intraarticular Effusion

Similar to the anterior side, especially a massive amount of joint effusion can be assessed from the posterior side as well. As the patient is lying prone, active flexion with counter-resistance may mobilize the fluid and make it (more) apparent. Like elsewhere, the examiner should be cautious while using the probe, because excessive compression might be misleading but—on the other hand—also necessary to evaluate its nature.[3]

Impingement and Intraarticular Loose Body

Various types of intraarticular lesions may produce a mass effect with subsequent impingement of neighboring anatomic structures in the posterior knee. The spectrum might comprise osteochondral body, ganglion cyst,[47,48] localized nodular synovitis,[49] lipoma,[50] exostosis,[51] and rheumatoid nodule.[52] Dynamic US is well suited for analyzing the behavior of a mass while the patient is asked to reproduce the snaps and/or other knee movements.

Posterior Cruciate Ligament

Similar to the anterior cruciate ligament, it can be evaluated statically and dynamically. Its thickening greater than 1 cm or hypoechogenicity might indicate injury, whereas focal disruptions or diffuse thickening might rather be suggestive of a tear.[7,9,53–55] During active movements together with the use of counter-resistance or posterior drawer test, the examiner can better evaluate the integrity (Video 23, http://links.lww.com/PHM/B929).

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