# *Ultrasound of the knee in Rheumatology: Pitfalls, what is new?*

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REVIEW

# Ultrasound of the knee in Rheumatology: Pitfalls, what is new? Use of US in Rheumatology

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## ABSTRACT

Ultrasound (US) of the knee is a valuable tool in examining patients with rheumatic diseases, in addition to clinical examination. Due to the rapid improvement of US equipment and the continuous upgrade of knowledge and experience in the field of musculoskeletal US, the US technique has been established as an indispensable tool in the clinical management of degenerative and inflammatory musculoskeletal diseases. Apart from the accurate visibility of anatomical structures, pathologic findings such as effusion, synovitis, enthesitis, erosions and osteophytes are readily depicted by US. During the last decade, aiming to assess treatment outcomes, the possibility of quantification of inflammatory findings using the US technique has been explored. The aim of this review is to illustrate the normal appearance of knee structures on US, consider potential pitfalls and review the recent literature about new prospects in knee evaluation as well as pathological findings in this region.

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## INTRODUCTION

The advantages of ultrasound (US) include its easy availability, cost-effectiveness and use of non-ionizing radiation. Additionally, patients with a contraindication to magnetic resonance imaging (MRI) (some types of pacemakers or implanted orthopedic hardware) can be examined by US. In these cases, US produces less artifacts than some types of musculoskeletal MRI.

The knee is considered to be one the easiest and most readily accessible joints for US application.[1] The US method has proved to be superior in both accuracy and reproducibility compared to clinical assessment,[2] adding a complementary aspect of imaging evaluation to the traditional modalities of plain radiography, computerized tomography (CT) and/or magnetic resonance imaging (MRI). Many studies have been conducted on the musculoskeletal anatomy and pathology since 1972, when the first US image of a human knee was published, aiming to differentiate a Baker's cyst from thrombophlebitis.[3]

Knee structures best suited for US assessment include tendons, muscles, ligaments, bursae, vessels and nerves. They should be assessed for their size, continuity, anatomic orientation and echogenicity, preferably compared to the contralateral side. Joint effusions, synovial thickening, bursal fluid collections, intra-articular loose bodies, ganglion cysts, tendonitis, ligament and tendons tears can be diagnosed.[4,5] Bony contours may be scrutinized for irregularities such as erosions, occult fractures or osteophytes. Masses of various textures (solid, cystic or mixed) may be found in this area. Ultrasound assessments are even more helpful if dynamic examination is applied. Colour (CD) or Power Doppler (PD) modalities may be used for assessment of the knee structures' vascularity. Radiography and CT provide much better evaluation of mineralization and the spatial relationship of fractures. Magnetic resonance imaging is invaluable for the assessment of bone marrow, bone tumors, and the evaluation of muscle and joint parts that are not accessible by US.

For the best possible evaluation of the knee joint, transducer frequency must be adequately adjusted. Although the linear transducer of high frequency is recommended for the standard scanning, use of high-resolution micro-convex-probes that fit better the anatomic concavity of the popliteal fossa is recommended for detection of meniscal tears in this region.[6] When linear structures (e.g., tendons, ligaments) are examined, the beam steering or compounding can help to overcome anisotropy. The minimum necessary pressure of the transducer should be applied in order to avoid collapse of the vessels and deformation of the underlying structures, guiding to misdiagnoses.

To provide valuable and accurate results, US requires a thorough knowledge of regional anatomy as well as of US technique. According to the EULAR guidelines, all main anatomical structures should be fully visualized using the 10 standard scans in both longitudinal and transverse views.[7]

## US PATHOLOGY

### Synovitis

The suprapatellar recess (Sr) is a synovial structure interposed in between the suprapatellar fat pad (Sf) and prefemoral fat pad (Pf). In normal conditions, it is depicted as a thin hypoechoic space as a result of collision of the anterior and posterior synovial membranes. Detection of a small amount of fluid is much more accurate and reliable using US than by physical examination. Fluid volume less than 6-8 ml may be omitted clinically.[8] Small amounts of synovial fluid may be preferentially located into the parapatellar joint recesses, so these points should be regularly checked out for possible effusion.[9]

According to OMERACT,[10] an effusion is defined as an abnormal hypoechoic or anechoic compressible and displaceable intraarticular material that does not exhibit PD signal. If the longitudinal diameter of the suprapatelar recess (Sr) overcomes 3mm, it is considered pathologic.[11] For detection of small amounts of fluid (<3ml), the dynamic maneuver, by applying the active contraction of the quadriceps muscle which induces cranial displacement and accumulation of fluid, should be performed.[12]

Synovial hypertrophy is defined as an abnormal hypoechoic, non-displaceable and poorly compressible intra-articular tissue that may exhibit PD signal (**Figure 1**).[13] Therefore, in order to differentiate displaceable fluid content from the non-displaceable synovial hypertrophy, diagnostic compression with the transducer is recommended.[14] The PD or CD-US signal may not be present in the case of synovial hypertrophy due to relatively deep position of the knee. However, if present, the PD/CD-US finding is strongly indicative of active inflammation.

### Osteoarthritis

Ultrasound has proved to be a valuable tool in depicting and quantifying some early and late osteoarthritis (OA) changes in the cartilage, bone profile, synovial tissue, tendons and ligaments. In normal conditions, the trochlear hyaline cartilage is depicted as a homogenous, hypo- to anechoic band, thicker in the central part and with a sharp superficial surface. Its mean thickness varies between 1.8 and 2.5mm depending on the subjects' gender and body type (**Figure 2**).[15,16]

Osteoarthritis is characterized by focal degeneration and progressive loss of the articular cartilage. Depicted by US, cartilage pathology is characterized by loss of sharpness of the surface facing the joint cavity, focal or

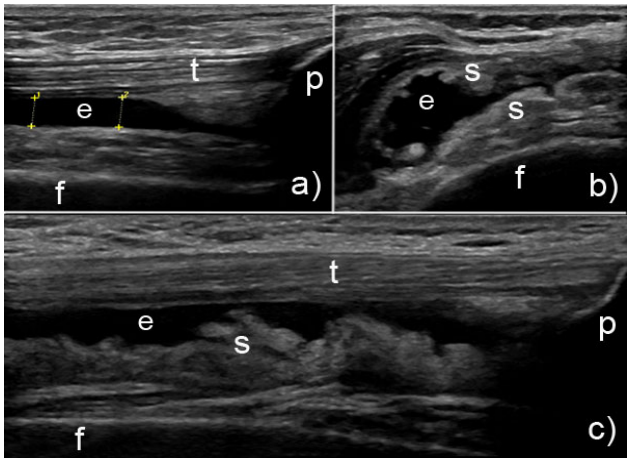


**Figure 1.** Knee synovitis. a) effusion of the suprapatellar recess - long scan, b) chronic synovitis of the suprapatellar recess with increased thickness of the synovial layer - short scan, c) chronic synovitis of the suprapatellar recess with increased thickness of the synovial layer - long scan: t - quadriceps tendon; p - patella; f - femur; e - anechoic appearance of fluid present within the suprapatellar recess; s - hypertrophied synovial layer.

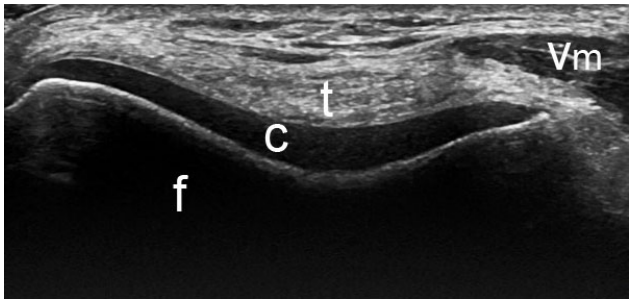


**Figure 2.** Transverse view of the trochlear cartilage: f - femur; t - quadriceps tendon cross section; c - trochlear cartilage; Vm – cross section of the vastus medialis muscle.

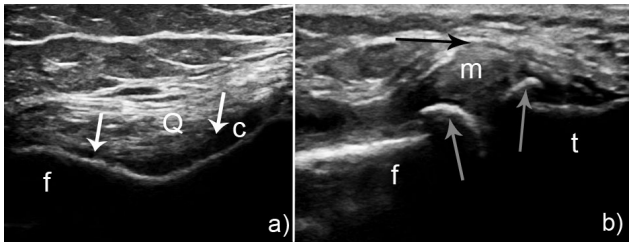


**Figure 3.** Knee OA. a) transverse scan of the femoral trochlea, b) medial longitudinal knee scan: f - femur; Q - quadriceps tendon cross section; c - trochlear cartilage; t - tibia; m - medial meniscus; black arrow - medial collateral ligament; gray arrows – osteophytes; white arrows – irregular anterior cartilage surface.

diffuse reduction of cartilage thickness and loss of homogeneity as a result of the water content loss (**Figure 3a**). Osteophyte (the typical OA finding) is defined as a step-up prominence at the end of the normal bone contour or at the joint margin, with or without acoustic shadow (**Figure 3b**), seen in 2 perpendicular planes.[13] Erosions, that may be seen as well, are cortical breakages with a step-down contour defect seen in 2 perpendicular planes.[13]

Inflammatory findings (synovitis and/or bursitis) can complicate the clinical image of OA. Depicted by US, they correlate well to advanced radiographic disease according to the Kellgren-Lawrence scale suggesting an inflammatory pathway for OA. However, in almost 50% of patients no signs of inflammation are detected.[17,18]

The meniscal protrusion, mainly limited to the medial knee compartment, is an indirect sign of the joint space narrowing.[13] It results in the medial collateral ligament (MCL) medial displacement and hypoechoic appearance. Medial collateral ligament bursa may be detected as an anechoic, elongated area whose thickness depends on the amount of fluid in the cavity. Meniscal or parameniscal cysts, which are usually non-compressible and non-displaceable, are seen adjacent to the menisci.

**Enthesopathies and tendinopathies**

None of the tendons in the knee region are invested with synovial sheath. Therefore, the most frequent pathologies seen are tendinopathies and paratenonitis. Tendinopathy refers to the tendon degeneration and it should be distinguished from tendinitis, which is an acute inflammation of the tendon.

The quadriceps tendon (Qt), positioned at the anterior aspect of the knee, should be evaluated from its myotendinous junctions to the patellar attachment with the knee slightly flexed,[19] so that the tendon is depicted as a hyperechogenic, fibrillar and homogenous structure (**Figure 4a**). If the knee is in neutral position, Qt

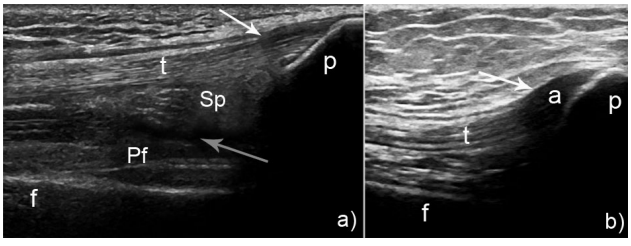


**Figure 4.** Suprapatellar longitudinal knee scan. b) the knee in flexion, a) the knee in neutral position: t - quadriceps tendon; white arrow - the anterior surface of the quadriceps tendon; a - area of anisotropy; p - patella; f - femur; Sf - suprapatellar fat pad; Pf - prefemoral fat pad; gray arrow - suprapatellar recess.

becomes loose, acquiring a concave appearance. The hypoechoic area, depicted at the level of the patellar insertion as a result of anisotropy, may be confused with pathologic conditions (tendinopathy) (**Figure 4b**). Patellar tendon (Pt) is easily accessible by sonographic evaluation due to its size and superficial position. When the knee is flexed, Pt becomes tight and appears as a hyperchoic, fibrillar and homogenous structure (**Figure 5**). Its proximal and distal portions are normally thicker than the middle part, and this divergence should not be assumed as a pathologic one.[20] Field-of-view imaging allows the demonstration of the entire length of the area, matching MRI's ability[16] to display a large anatomical region.[21,22]

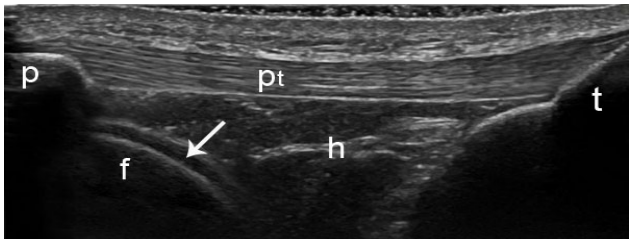


**Figure 5.** Long view of the normal patellar tendon: pt - patellar tendon; p - patella; f - femur; t - tibia; h - Hoffa's fat pad; white arrow - trochlear cartilage.

As a result of repetitive strain, micro-tears and collagen degeneration due to microtrauma or inflammatory conditions, tendinopathy of the proximal patellar insertion is frequently seen. This condition, referred as "jumper's knee", is characterized on US by presence of a hypoechoic area at the proximal tenondial portion. Due to presence of neovascularization, a Doppler signal can often be detected.[21] Diffuse tendon thickening and hypoechoic appearance may be the result of metabolic or inflammatory diseases as well as of the chronic, mechanical and jumper's knee postsurgical state.

The iliotibial band (ITB) is visualized proximally to Gerdy's tubercle,[22] as a hyperechoic, thin, fibrillar structure. No significant correlation between the ITB thickness and the subjects' age, weight, height, dominant limb and sporting activities has been reported.[23] A triangular hypoechoic contour that the ITB tendon acquires (**Figure 6**) just before the attachment, must not be assumed as a pathologic one (e.g., tendinopathy).[24] A joint recess may be seen right underneath the ITB and it should not be mistaken for a meniscal cyst, since this is an area where meniscal cysts typically occur. While the recess may extend superiorly toward the lateral femoral condyle, following the ITB from underneath, it should not be mistaken for evidence of bursitis, whereas a similar US image may be seen in ITB friction syndrome.

The Bf tendon that inserts into the fibular head is visualized as a superficial, homogenous, hyperechoic cord. The Bf tendon bifurcates into two parts (superficial and deep), enveloping the distal portion of the lateral collateral ligament (LCL), visualized as a hypoechoic, fibrillar cord. These divergent superficial and deep parts of the Bf are visualized as an enlarged triangular structure of mixed echogenicity, simulating appearance of "tendinosis" due to the tendon "thickening" and anisotropy.[25] This should not be assumed as a regional pathology.[26] Apart from tendinopathies, the Bf tends to be the most frequently injured hamstring tendon.[27] This is explained by the different nerve supply of the two Bf heads and their consequent poor neuromuscular coordination that leads to their greater susceptibility to injury.[28]

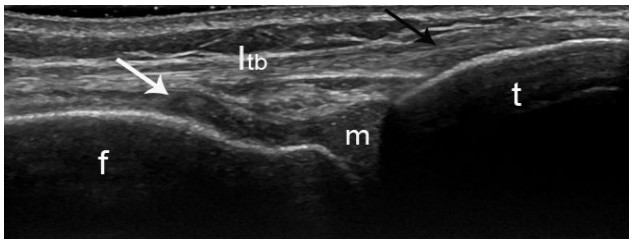


**Figure 6.** Long view of the iliotibial band (ltb): f - femur; t - tibia; m - lateral meniscus; ltb - iliotibial band; black arrow - point of ltb attachment; white arrow - joint recess.

The semitendinosus (St) and semimembranosus (Sm) tendons are medial structures of the posterior knee.[26] The superficially positioned homogenous, hyperechoic, fibrillar, relatively thin tenondial cord of the St is easily visualized [31,32] If present, chronic tendinopathy of the St tendon is characterized by diffuse and focal thickening with hypoechoic changes. By using the St tendon for the anterior cruciate ligament reconstruction, it is proved that this tendon can regenerate with histologically demonstrable tenocytes.[29] The CD or PD modalities can be used to assess neovascularization, inflammation and healing.

The Sm tendon is located underneath the St. Although all studies do agree on three tenondial expansions, few of them claim that the Sm tendon possesses up to 8 distal attachments.[30] Evidently, the Sm tendon fans out at the level of the posterior articular space, producing a triangular hypoechoic appearance that should not be mistaken for a regional pathology. Increased thickness of the Sm tendon, hypoechoic appearance and deranged echotexture, as well as the presence of calcifications at the site of clinical tenderness, may be findings suggestive of pathology.[31]

By short axis scan, the St is visualized as a small, hyperechoic rounded area positioned superficially to the much larger, oval Sm tendon. The medial Gc tendon is

displayed as a comma-shaped hypoechoic structure that points out in-between the St and Sm tendons. All 3 tendons are positioned in opposed topographic directions so that the US beam hits them in a different angle, producing dissimilar echogenicity. Thus, when the St and Sm tendons are depicted as hyperechogenic structures, the Gc tendon is depicted as a hypoechogenic one and vice-versa. These findings should not be misinterpreted as tendon pathology.[31,32]

Inflammation of the tendon insertion (enthesitis) is widely considered as the hallmark of spondyloarthropathies (SpA). Enthesopathy on US is defined according to the OMERACT criteria, as an abnormally hypoechoic and/or thickened tendon or ligament at its bony attachment that may exhibit Doppler signal[13,33] and/or bony changes including enthesophytes, calcifications, erosions and irregularities.[34] In the knee, the patellar tendon seems to be involved more frequently than the quadriceps one.[33] For quantification of enthesitis, various US scores have been proposed. B and Colour mode evaluation of the patellar Qt and both Pt insertions, as well as of the suprapatellar and infrapatellar bursitis, are used.[35,36]

Morphologic abnormalities of enthesitis and bursitis are active inflammatory lesions responsive to the biologic therapy and produce PD signal. Therefore, US should be considered a valuable tool in patient follow-up. Numerous US scores, based on semi-quantitative measurements in included joints (in a scale of 0 to 3), have been created.[37,38]

**Bursitis**

By definition, a bursa is a small sac lined by synovial membrane with an inner capillary layer of synovial fluid. Bursae provide a cushion between various anatomical structures allowing their free movement. In normal conditions, superficial knee bursae (prepatellar and infrapatellar) cannot be demonstrated due to the fluid absence in their cavities. While the bursal synovial walls are very thin, even a minimal compression to the bursae leads to fluid extraction from the compressed part to peripheral non-compressed areas, so that the effusion as well as any inflammation (assessed by Doppler mode) may be missed. Superficial bursitis is mainly a consequence of post-traumatic impact or chronic irritations while the deep infrapatellar bursitis usually accompanies the pathology of the patellar tendon and enthesis of the infrapatellar area.

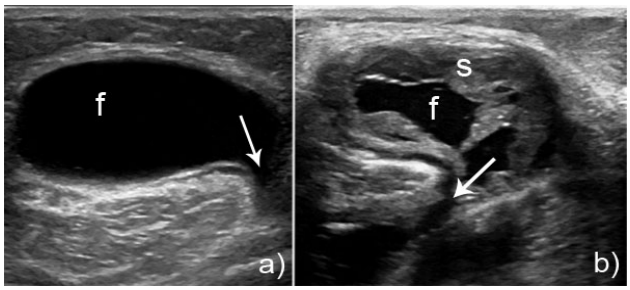


**Figure 7.** Baker's cyst. a) transverse scan of the acute Backer's cyst, b) transverse scan of the chronic Baker's cyst: f – anechoic appearance of fluid within the cyst cavity; s – hypertrophied synovial wall of the cyst; white arrow – Baker's cyst's pedicle (neck).

The deep infrapatellar bursa (detected in more than 65% of the knees) is depicted as a triangular anechoic structure, located behind the distal segment of the Pt. The mean anteroposterior and craniocaudal bursal dimensions are 2.1-2.7 mm and 7.3-9.1 mm respectively, and no statistically significant differences in thickness between genders or knee sides have been reported.[39] This appearance is assumed as a normal one if the bursa is asymptomatic and if the anechoic area is present bilaterally.

Sartorius, gracilis and semitendinosus tendons insert onto the anteromedial surface of the tibia, playing a significant role as stabilizers of the medial side of the knee in the upright posture. This complex is named pes anserinus (PA), or "goose foot", from the pronged manner of the conjoined tendon insertion.[40] The anserine bursa is a set of several synovial bursae located among each of the tendons and between the PA and the tibial bone. Bursitis is a common cause of discomfort in elder patients, clinically diagnosed in almost 47% of the patients with OA. In contrast, in more than 83% of cases with tendinitis or anserine bursitis, US evidence of knee OA has been found,[41] predominantly in middle-aged women.[42]

The most important knee bursa located between the Sm tendon and the medial head of the gastrocnemius (Gc) tendon is the semimembranosus-gastrocnemius (Sm-Gc) bursa. In pathological conditions, this cyst (called Baker's cyst) presents as a distended mass located in the medial corner of the popliteal fossa. Its prevalence varies between 20% in general population and 48% in patients with knee pathology. Patients with a popliteal cyst had a significantly higher prevalence of medial meniscal tears (70% versus 19%) and chondral lesions (85% versus 28%).[43,44] Identification of fluid between the Sm and medial Gc tendons in communication with a posterior knee cyst indicates Baker's cyst with 100% accuracy.[47,48] In children, the cyst may be primary, while in adults it is associated with a chronic effusion, coexisting with an intra-articular disorder. The joint fluid accumulates in the bursa in knee flexion and cannot go back into the joint cavity due to the one-way valve mechanism. Baker's cyst is visualized sonographically as an anechoic structure located between the medial head of Gc and Sm tendons. Dynamic assessment (knee flexion) may help to demonstrate the

cyst's pedicle that represents the connection between the deep bursal component and the joint cavity.[45] Baker's cyst may extend into thigh and/or calf muscles and induce popliteal neurovascular bundle compression or may rupture into the calf, mimicking a deep vein thrombosis. Differential diagnosis can be readily accomplished by US.
Baker's cyst may contain an anechoic fluid or hypoechoic synovial tissue due to synovial hypertrophy. Loose joint bodies of various echotexture can be detected within the cyst. Clinically, patients may be asymptomatic if Baker's cysts develop slowly. In inflammatory arthritis, it regresses together with knee synovitis, responding to treatment.

**Crystal-induced arthropathies**

Various crystals may be associated with joint and soft-tissue pathology due to their deposition in and/or around joints, inducing an inflammatory response. The most common types of crystal-induced arthropathy are calcium-pyrophosphate-dihydrate (CPDD) deposition disease and gout. The latest one is induced by basic-calcium-phosphate-dihydrate crystals, which can cause acute inflammatory attacks of arthritis or periarthritis. Oxalate-crystal deposition disease is rarely seen, in patients with primary hyperoxaluria and in patients with end-stage renal disease. Each of these arthropathies has a characteristic clinical presentation, different crystal type (aspirated from affected tissues) and radiographic appearance.
Calcium-pyrophosphate-dihydrate crystals are mainly deposited in fibrous and hyaline cartilages, causing an acute attack of synovitis, preferably in the knees. Calcium-pyrophosphate-dihydrate crystal deposition disease (pseudo-gout) is usually idiopathic, more frequently seen in women[46] and may evoke both acute or chronic arthritis. Disease attacks may be precipitated by any intercurrent illness, recent surgery and trauma, or even by local treatment of OA with intra-articular injections of hyaluronic acid preparations. Knee X-rays reveal typical calcification of the meniscus (equally sensitive or specific as US), while joint synovial fluid examination reveals the typical positively birefringent CPPD crystals on polarizing light microscopy.
On US, CPPD crystal depositions within the articular cartilage are displayed as a thin hyperechoic band (chondrocalcinosis), parallel to the surface of the hyaline cartilage preferably limited to the mid-third of the cartilage thickness (**Figure 8a**).[47] Calcium-pyrophosphate-dihydrate depositions in the fibrocartilage are visualized as a punctuated pattern (**Figure 8b**); whereas within tendons they appear as tiny hyperechoic dots and/or lines arranged among the tenondial fibers.
Deposition of monosodium urate (MSU) crystals causes gouty arthritis in one or more joints. When left untreated, crystal depositions lead to recurrent episodes of joint inflammation and joint destruction. The clinical manifestations of gout may be subdivided into early and late presentations and acute and chronic attacks of arthritis. In gout synovitis, joint fluid is anechoic only at the first gouty attack; afterwards, the synovium begins to proliferate. Synovial fluid may be displayed as completely anechoic or filled with aggregates of variable shape ("starring night") and echogenicity - "snow storm" (SS) appearance. Bursitis has chronic features from the beginning.
"Double contour sign" (DCS), which is now accepted as a specific gout finding, is characterized as a focal or diffuse enhancement of the superficial margin of the articular cartilage as a result of MSU crystal deposition (**Figure 9**).

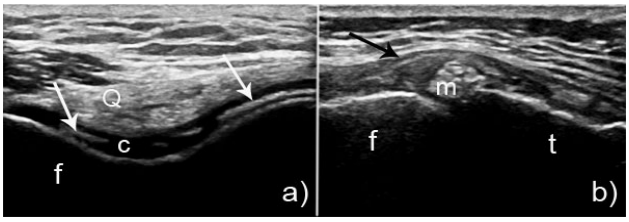


**Figure 8.** Knee CPPD disease. a) Transverse view of the trochlear cartilage: f - femur; Q - quadriceps tendon cross section; c - trochlear cartilage; t - tibia; m - medial meniscus with the patchy echotexture, mostly hyperechogeni,c due to the CPPD; black arrow - medial collateral ligament; white arrow - hyperechoic band (chondrocalcinosis) due to the CPPD.

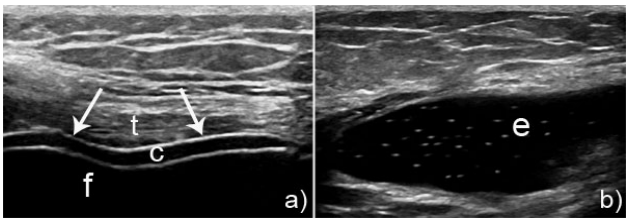


**Figure 9.** Gout. a) Double contour sign (DCS) image, b) "starring night" image: f - femur; t - quadriceps tendon cross section; c - trochlear cartilage; white arrows - enhancement of the superficial margin of the articular cartilage as a result of MSU crystal deposition; e - anechoic appearance of fluid and hyperechoic aggregates of variable shape, present within the suprapatellar recess.

The US appearance of tophi depends on their size and the time of their generation. At early stages, tophi are depicted as small, hypoechoic and homogenous nodules. Later on, tophi become echoic with hyperechoic

edges and finally appear as pseudotumoral and inhomogeneous masses. Depiction of the DCS, tophi, SS and starring night image has been recognized as diagnostic, establishing US as a useful tool in recognizing the articular and juxta-articular changes in gout.[48]
Evaluation of multiple joints improves diagnostic sensitivity for CPPD and gout; therefore, US imaging should not be limited to the symptomatic joint.[49] The first MTP joint is the most common site for US signs for gout in symptomatic and asymptomatic joints.
There is a small subgroup of patients with crystals of both types (MSU and CPPD) found in the joint fluid. In these patients, in symptomatic joints, US signs of either diseases or one of them may be found. If US is performed on multiple joints, all patients will present US signs of at least one of the diseases.[49]
Although the gold standard in diagnosis of crystal-induced arthropathy is the presence of crystals in the joint fluid, US is a very helpful imaging method, adding valuable information to the patient's clinical and biochemical profile.

## LIGAMENT AND MENISCUS PATHOLOGY

The medial collateral ligament (MCL) is the primary static stabilizer against valgus rotation of the knee joint. It consists of the superficial MCL (sMCL) and the deep part (dMCL). The sMCL connects the medial tibia and femur, while the dMCL stabilizes the medial meniscus (mM) against the adjacent bones. On US, MCL appears as a 1-3 mm thick elongated band matching its anatomic arrangement. It appears with a specific echotexture displaying two hyperechoic layers separated by a hypoechoic one (**Figure 10**). The thin hypoechoic layer interposed between the two hyperechoic ones is related to the fatty tissue and the synovial MCL bursa, described in up to 100% of cadaveric knees.[50]

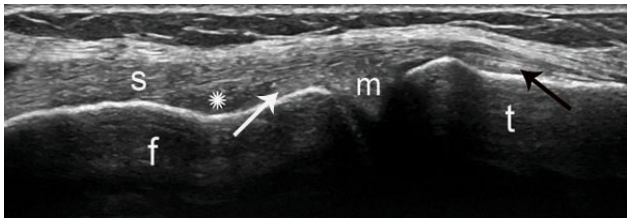


**Figure 10.** Medial collateral ligament (MCL) long view. s - superficial MCL layer; f - femur; t - tibia; m - medial meniscus; asterisk - fatty tissue containing the MSL bursa; white arrow - meniscofemoral ligament (proximal part of the deep MCL); black arrow - meniscotibial ligament (distal part of the deep MCL).

The medial meniscus (mM) is visualized as a triangular hyperechoic structure wedged in between hyperechoic borderlines of the femur and tibia.[51] Although at present US cannot be a routine test for meniscal imaging, it is now proved that additional information may be provided using the axial mM scan.[52] Suggestions of using US as an effective screening tool for detecting mM tear in young patients (<30 years old) have been lately stated.[53] According to the later study, patients with negative US findings may need no further investigation considering the meniscal lesion. In general, a meniscal protrusion and fissurations (tears) can be easily diagnosed with an overall accuracy of more than 70%, while cysts (with sensitivity of 82%)[54] can be punctured and aspirated by US guidance,[55] especially when the dynamic approach is performed.[56] The dynamic approach, based on meniscal irregularities or calcifications, has also proved to be valuable for the detection of meniscal degeneration.[57]

## NERVE PATHOLOGY

One of the major components of the posterolateral knee corner is the common peroneal nerve (CPN). The CPN is a lateral division of the sciatic nerve which, shortly after its origin, joins the posteromedial border of the Bf muscle, and in advance following the Bf tendon, descends toward the fibular head (**Figure 11**).

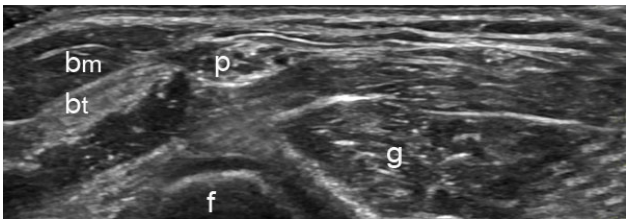


**Figure 11.** Posteriorolateral aspect of the knee (short scan): f - fibular head; bt - biceps tendon; bm - biceps muscle; g - lateral gastocnemius muscle; p - common peroneal nerve

Using the Bf as a landmark, the CPN is easily visualized, preferably in transverse scans, by using high frequency probes that allow a detailed evaluation of the nerve's morphology. At the level of the fibular head, the CPN splits into two terminal branches: the superficial and the deep one, with all three branches positioned in-between the skin and the fibular bone and therefore being vulnerable to injuries.[58,59] Unlike with MRI, by US, the entire length of the peripheral nerve can be imaged in a relatively short time.
The tibial nerve, which may also be evaluated by US, is located as the most superficial and most lateral structure of the posterior-central popliteal zone.[52]

## NOVEL USES OF US

Ultrasound may be a useful tool in the patient's post-surgical follow-up, detecting complications like

abscesses, hematomas or oedema. Ultrasound allows needle guidance in procedures such as aspirations or biopsies.[60,61] Knee arthrocentesis guided by US minimize attempts and improve procedural confidence in the hands of non-experienced phyisicians.[4] The US-guided injections evade tendons, ligaments and bony structures, rendering arthrocentesis a simple and painless procedure.[62,63] Accuracy of intraarticular injections, by use of US, may be improved up to 95.8% (versus 77.8% for anatomical guidance [p<0.001]),[64-66] resulting in complete joint decompression and improving clinical outcomes.[67,68]

Monitoring of patients with inflammatory arthritis and quantification of disease activity using clinical scores are very important issues in Rheumatology.[69-72] Use of the PD modality allows the identification of patients with inflammatory arthritides in clinical and histological remission after tapering and discontinuing biologics, especially when combined with clinical assessment.[73-75] This strategy may minimize the risk of ongoing joint damage in patients who reduce therapy.[76] As proved, PD modality also can become a useful means to appreciate enthesitis in SpA.[77,78]

## CONCLUSION

Ultrasound, with its exquisite resolution, allows a detailed assessment of the anatomical structure as well as of the regional knee pathology. Therefore, US should be performed in all patients with inflammatory and degenerative diseases in clinical practice and for research purposes. Ultrasound allows fast and accurate imaging of joints and related structures leading to detection of joint inflammation, assessing ongoing disease activity and monitoring of therapeutic responses. Ultrasound evaluation enhances the possibility of detecting and aspirating small amounts of fluid that are not always easily detected with clinical examination. This is a strong reason for the integration of US imaging techniques in Rheumatology.

## CONFLICT OF INTEREST

The authors declare no conflict of interest.

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