Ultrasound of the knee in rheumatology

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Abstract

Knee ultrasound is a very useful tool for the clinical examination of rheumatic patients. In the last years many papers have been focused on this subject, exhibiting a high degree of improvement since the first musculoskeletal ultrasound paper concerning the knee was published 30 years ago. Apart from the accurate description of anatomic landmarks and structures and also of the basic pathological findings (fluid, synovitis, enthesitis, osteophytes), rheumatologic research has focused on inflammatory findings quantification and their reaction to remissive treatments. The aim of this review is to describe the normal ultrasonographic appearance of knee structures concisely and mainly to analyse the literature about pathological findings in the knee joint.

Keywords: ultrasound, knee, anatomy, pathology

Introduction

Although the knee is widely considered to be the most accessible joint for clinical examination, knee ultrasound (US) was proven to be superior in both accuracy and reproducibility when compared to the clinical exam [1].

Being a relatively deep joint, the use of low frequency probes is recommended for knee US. The first published US image of a human joint referred to the knee, specifically to differentiate Baker’s cyst from thrombophlebitis, and was performed in 1972 [2]. Since then, many papers have focused on this subject and discovered elements of anatomy and main pathology of the knee.

The aim of this review is to analyse the recent literature on this subject, focusing first on a brief description of the knee anatomy, and then on the most relevant pathologic aspects of rheumatic disease.

US scanning technique

Standardized scanning of the knee is performed with a linear 5-13 MHz transducer, except for the most superficial structures that might need a 15 MHz probe [3]. The patient’s position depends on the area depicted: dorsal decubitus with a slight knee flexion for the anterior side and ventral decubitus with extended knee for posterior side.

US anatomy

For didactic reasons, the knee will be divided in four compartments: anterior, medial, lateral, and posterior. The main anatomic structures from these compartments are summarized in tables I and II together with the transducer position in order to maximize their visualization (table I) and the ultrasonographic correspondent image (table II). US assessments are more helpful if the ex-
aminations are dynamic, covering most of the region of interest, and if depicted structures (muscles, tendons, ligaments, nerves, cartilage, menisci, and cortical bone) are visualized in their entire length. Moreover, since panoramic views are available on most of the recently used US machines, it is now possible to depict in one image the whole length of a structure, regardless of its dimensions. US representative images of anterior and medial compartments are visualised in figures 1-3.

Table I. Main anatomic structures and related ultrasonographic scans

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<th>Compartment</th>
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<td>Pes anserine insertion (Pa)</td>
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<td>Gastrocnemius tendon (Gt)</td>
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<td>Popliteal artery and veins (PV)</td>
<td>Transverse scan</td>
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**Fig 1.** Ultrasound of the knee in a healthy individual. Longitudinal anterior scan at the suprapatellar recess level. Normal quadriceps tendon (↑) and normal amount of synovial fluid (*) are visualized. F: femur; P: patella

**Fig 2.** Ultrasound of the knee in a healthy individual. Transverse suprapatellar scan. Normal hyaline cartilage of the femoral condyles (o) is visualized.

**Fig 3.** Ultrasound of the knee in a healthy individual. Longitudinal scan of the medial aspect of the joint. Normal medial collateral ligament (†) and normal internal meniscus (*) are visualized. F: femur; T: tibia

**US pathology**

1. **Joint effusion and synovial hypertrophy**

An amount of fluid of more than 3 ml can be depicted in the knee joint with US [3] (fig 4). Three recesses of knee synovia are visualized by US on the anterior part of the knee: suprapatellar, parapatellar lateral, and parapatellar medial. As fluid is displaceable, care should be taken to avoid pressure with the probe. The
usual knee fluid assessment starts with the suprapatellar recess, and continues with the lateral and medial recesses, as they are the most dependent when the patient is in dorsal decubitus. After effusion detecting, compression with the transducer is recommended, in order to differentiate between fluid and synovial hypertrophy (fig 5), which is not displaceable. The development of Power Doppler US (PDUS) technique has lead to improving information regarding the local activity, knowing that PDUS detects inflamed tissues hyperemia. The knee is a relatively deep joint, so PDUS signal is not always present in case of synovitis. However, its presence is indicative of active inflammation.

The superiority of US examination over clinical exam in the swollen knee was proven first by Hauzeur et al [1], and a few years later by Kane et al regarding Rheumatoid Arthritis (RA) fluid in the knee [4]. This applies for suprapatellar recess, parapatellar lateral and medial,
and Baker cysts. On the other hand, clinical exam proved itself to underestimate knee inflammation.

Effusion is defined by OMERACT as an abnormal hypoechoic or anechoic intraarticular material that is compressible and displaceable and does not exhibit Doppler signal. Synovial hyperthropy is defined as an abnormal hypoechoic intra-articular tissue that is nondisplaceable and poorly compressible and may exhibit the Doppler signal [5]. The dimensions can be evaluated by the direct measurement of knee effusion at its greatest point of thickness inside the suprapatellar recess [6], and in that case a >3mm diameter of suprapatellar recess is considered pathologic [7].

The presence of the PDUS signal inside the knee joint can be used to differentiate between hypervascular and fibrous pannus, but it might not always be accurately visualized, mainly because of the deep location of the joint. Fiocco et al proved that by using contrast enhanced Doppler (CED), the method has enhanced reliability, consistently reducing artefacts, when comparing to arthroscopy as the gold standard [8]. However, the use of contrast agents can be considered time consuming and therefore cannot be used in daily practice.

Knee synovitis in RA is sometimes refractory (persistent for more than 6 months of aggressive local and systemic treatment) or relapsing during the treatment, and that may cause great damage to the joint, leading frequently to arthroplasty. This is another important reason for the indication of repeated examinations of the knee joint by US especially in RA. As quantification of disease activity in RA is an important issue nowadays for starting or monitoring biologic treatment, US became very important together with clinical scores for global evaluation. More than 10 different US scores were defined in the last years, including different joints, mostly hand joints. The knee was also included in some of these scores [9-11]. The possibility of developing US scores emerged from the description of the semiquantitative scale as a quantifying method with high reproducibility [12]. US scores are based on adding the values of semiquantitative grades in specific joints (from a scale 0-3). This modality of quantification being relatively easy, can be applied to large joints as knee as well.

US is frequently used to evaluate the therapeutic intervention in the RA knee. Fiocco et al tested the specific action of Etanercept on RA and Psoriatic arthritis patient’s knees, in patients with persistent knee synovitis after methotrexate and other DMARDs. The conclusion was that Etanercept can suppress persistent knee synovitis in most patients [13]. Regarding PDUS, the study reported the decrease in vascularization first in the superficial layer of knee pannus, and later in the deeper one. The separation between the two layers of inflammation inside knee synovitis was reanalysed by Kasukawa et al [14]. Superficial flow signals were defined as located in the superficial half of the pannus and fluid space whereas deep flow signals were located in the deep half of the pannus. Joints with superficial pattern had a higher flow signal and a higher synovial effusion grade, whereas joints with deep pattern had a higher grade of synovial proliferation.

In a systematic review focusing on the responsiveness of knee arthritis to therapy, Keen et al [15] reviewed the studies in which US synovitis of the knee was assessed (Gray Scale and PD) before and after a therapeutic intervention. The authors defined internal responsiveness as the ability of an outcome tool to demonstrate temporal changes in response to therapy and external responsiveness as the extent to which changes in an outcome tool correlate with other referenced measures [15]. US of the knee demonstrated internal responsiveness with regard to synovial thickness, effusion size and popliteal cyst size.
The most encountered knee tendon pathology in rheumatology is the inflammation of their bony insertion known as enthesitis, widely considered as the hallmark
for spondylarthropathies (SpA). It is also known that enthesitis may affect primarily lower limbs, knee together with the heel being the most frequently affected joints.

US definition of enthesopathy includes an abnormally hypoechoic and/or thickened tendon at its bony attachment, occasionally with calcifications, seen in two perpendicular planes that may exhibit a Doppler signal, and also bony changes – enthesophytes, erosions or irregularities [5] (fig 4). The inflammatory enthesopathy is known as enthesitis and it has been widely studied with US, mostly since biologic treatment emerged in SpA and had to be objectively monitored.

The quadriceps tendon insertion and the patellar tendon/ligament both insertions, as well as suprapatellar and infrapatellar bursitis were included in the GUESS score, one of the first available US scores to quantify enthesitis [27]. The study found numerous subclinical enthesitis in SpA and proved US to be more sensitive and more specific than clinical examination. GUESS score, consisting only in Gray Scale examinations, was proven reproducible for treatment evaluation of SpA patients, but values obtained did not correlate to systemic parameters of disease activity, like in RA.

Adding PDUS to knee enthesitis evaluation, D’Agostino et al found abnormal vascularization in 81% out of 164 consecutive SpA patients; in the knee, quadriceps tendon was less affected than patellar tendon [29]. An important conclusion of the study was that US shows enthesitis signs ( PDUS) mostly in SpA patients with peripheral form of disease – psoriatic arthritis and reactive arthritis [28,29].

Regarding enthesitis response to treatment, Naredo et al investigated a group of 327 patients with SpA before and after anti-TNF alfa treatment. They concluded that enthesis morphologic abnormalities, PD signal and bursitis are active inflammatory lesions responsive to biologic therapy, and calcifications and bone lesions are not responsive, being them as structural damage lesions [30]. The same three enthesis points were included from the knee. Together with enthesitis, the presence of synovial effusion was also considered as inflammatory, being reversible to treatment.

Enthesitis of the quadriceps tendon was found also in RA patients [31], less common than in psoriatic patients, and always accompanied by effusion. Also, inflammatory signs previously described appear more often in RA whereas in psoriatic arthritis patients exhibit more structural damage.

**4. Bone and cartilage abnormalities**

Knee osteoarthritis is one of the most encountered diseases among general population, with a women pre-dilection. The most specific US sign for osteoarthritis are the osteophytes, defined as step-up bony prominence at the end of the normal bony contour or at the margin of the joint seen in two perpendicular planes, with or without acoustic shadow [27] (fig 6). In the knee joint, the place to look for osteophytes is the tibiofemoral joint. In advanced disease, osteophytes can permanently compromise the joint structures (capsule, menisci or ligaments), leading to secondary pathology (ligament rupture, meniscal clefts or meniscal cysts). The indication for US is in the early stage of the disease, mainly for diagnosis.

Cartilage at the knee joint has a thickness of about 3mm [27] (fig 2). Signs of deterioration appear on US as blurring, loss of sharp contour, and margin irregularities. Usually in osteoarthritis the cartilage is asymmetrically thinned, being more symmetrically affected in RA. Knee cartilage is best visualized at the patellar level, with hyperflexed knee, and also from the posterior view, along femoral condyles.

US was recently proven to be very accurate in cartilage depiction of knee condylar cartilage in cadaver specimen [32].

**5. Knee joint injection**

Intraarticular joint injections of the knee are performed frequently in rheumatologic daily practice. The placement of the needle must be strictly inside the joint, no matter if the maneuver is for aspirating fluid or for therapeutic agents injection (corticosteroids or viscosupplementation substances). Only 56-85% of intraarticular (IA) injections are correctly placed [33,34], without using an imaging modality to guide the needle. Other studies demonstrate a higher rate for non guided IA knee injection – up to 93% [35-37]. Sonographic needle guidance has been proven to enhance clinical outcomes (pain control) and cost-effectiveness of the procedure [36]. Balint et al reported a 4/10 rate of success in a blinded aspiration of the knee, compared to 18/19 when using US [37].

![Fig 6. Ultrasound of the knee. Longitudinal scan of the medial aspect of the joint showing the presence of an osteophyte (↑). Normal internal meniscus (*) is also visualized. F: femur; T: tibia](image-url)
In a systematic review, Hermans et al [38] included nine studies on the matter of needle placement inside knee joint. The most accurate (and the most used) approach of the knee is the superolateral one, with the knee in extension, resulting in a 91% pooled accuracy. Other approaches are lateral mediopatellar, anterolateral and anteromedial approach, which showed a lower accuracy. A medial patellar approach was used by Sang Hee et al to guide intraarticular hyaluronan in a dry knee- the guided injections had an accuracy of 95.6% compared to 77.3% in blinded injections [39].

The main agents used for knee IA injections are corticosteroids, both in refractory synovitis in inflammatory conditions (RA, SpA, PsA) and for symptomatic relief in OA. IA corticosteroids are recommended by ACR guidelines of knee RA/ OA treatment since 2000 [40,41]. US guided knee injection is able to improve the accuracy from 82% in a blinded manner to 91%, even if the rheumatologist was a young doctor with basic US training in the Cunnington et al study [42]. The minimal difference between the two types of procedure was only obtained for the knee, suggesting that for the other joints the need for US guidance is higher.

The use of viscosupplementation for knee OA is also comprised in ACR guidelines for treatment [40]. Hyaluronic treatment is mostly indicated in painful knee OA with no or mild effusion [43]. US highly improves IA needle placement in such conditions, and its importance is augmented by the fact that the periarticular hyaluronic acid injection showed no improvement in knee pain.

Conclusion

US of the knee is a very frequently encountered procedure, both for clinical practice and for research purposes. Knee US, should be performed in all patients with RA as well as in OA, US evaluation of the knee enhances the possibility of detecting and extracting fluid. Recognizing the presence of knee effusion is not always easy at clinical examination. With US, even a beginner can obtain very good results in detecting knee effusion. In a recent study, 21 medical students were able to detect knee injected fluid on cadavers, after a few hours of teaching [44]. This is a strong reason for introducing US in rheumatology teaching process at all levels.

Conflict of interest: none

References