Ultrasound imaging for the rheumatologist
IV. Ultrasonography of the knee


ABSTRACT
Ultrasound examination of the knee is particularly useful in the detection of synovitis, early degenerative changes within the articular cartilage of the femoral condyles, calcifications within the articular cartilage layer and menisci, bursitis, and popliteal cysts. Also, important anatomical information about the structural integrity of the supporting tissues around the knee can be obtained by ultrasound in patients presenting with 'knee pain'.

We review the available evidence about the use of ultrasound in knee examination, provide information on the technical equipment and scanning methods and discuss the still controversial issues.

Introduction
The knee is one of the joints which can be extensively explored with ultrasound (US) due to the presence of wide acoustic windows which allow easy visualisation of different anatomical structures. The knee was one of the first sites of interest for musculoskeletal US in the 1970s and was initially used for the detection of Baker's cysts (1). The ease with which fluid collections in the popliteal fossa are detected, even with first generation equipment, has rapidly made arthrography obsolete. At present, a Medline search reveals that there are 1467 papers selected by the keys "ultrasound" and "knee". Most of the studies carried out by rheumatologists are focused on synovitis of the knee and underline the potential of US as a sensitive and reliable tool for the detection of knee inflammation (2-15). A comprehensive approach to knee US requires adequate training and experience because of the anatomical complexity of the joint and the related structures.

Indications
There is a broad spectrum of indications for US in the rheumatological setting (Table 1). In inflammatory arthropathies, US is particularly useful in the detection of sub-clinical synovitis (5-8). Early degenerative changes within the articular cartilage of the femoral condyles can be demonstrated in the setting of primary osteoarthritis (OA) and as a secondary phenomenon in inflammatory arthritis (16-25). Hallmark features of crystalline arthritis, such as calcification within the articular cartilage layer and menisci, are also easily seen with US (1, 26). Important anatomical information about the structural integrity of the supporting tissues around the knee can be obtained by US in patients with no previous rheumatic history presenting with 'knee pain' (27).

US equipment
Depending on the specific targets of the examination, a wide range of frequencies can be used. The choice is influenced by the size of the patient and the distribution of body fat. A balance between the use of low frequency probes for a panoramic view (i.e. fluid collection in the supra-patellar pouch) and higher frequency probes for a more detailed assessment of more superficial anatomical structures (i.e. patellar tendon, collateral ligaments and anserine tendon) is ideal.

Scanning technique
For US examination of the knee, the patient must be positioned supine on a bed or couch to allow the examination of the anterior and lateral compartments. The prone position must be adopted to permit exploration of the posterior compartment. According to the guidelines (28) there are 10 main ac-
ostic windows for US examination of
the knee. US access to the different
anatomical structures of the knee may
be tailored however, to include other
scanning planes according to the spe-
cific aim of the investigation and the
characteristics of the anatomical area
explored. This is particularly true for
the knee which is a large joint with
several ligaments and bursae and a
large articular surface which can be
difficult to study using only longitudi-
nal and transverse views. Longitudinal
and transverse scans are required to
ensure a detailed assessment of the key
findings of normal healthy cartilage.
Para-patellar and sub-patellar scans
may be useful for a better assessment
of parts of the weight-bearing carti-
lage. Sub-patellar transverse scans
should be performed with the knee in
the fully extended position.

US anatomy

Joints
The knee is the largest joint of the body
with an extended joint space. In healthy
subjects, a minimal amount of fluid can
be detected in the supra-patellar pouch
especially after active contraction of
the knee with the leg fully extended.
The supra-patellar pouch is a virtual ca-
vity and could be regarded as a bursa
from a physiological point of view. The
anatomical landmarks for its identifica-
tion are represented by the deep margin
of the quadriiceps tendon, the quadri-
ceps muscle and by a layer of connective
tissue interposed between the deep
wall and femoral bone profile. This
connective tissue has a homogeneously
hypoechoic structure, variable shape
and distribution which can generate mis-
interpretation, even being mistaken for
synovial proliferation in some cases.
Condylar cartilage is best assessed with
the knee preferably maintained in maxi-
mal active flexion. The cartilaginous lay-
er appears as a homogeneously anechoic
band with sharply defined margins. The
external margin is thinner and requires
adequate calibration of the US equipment
and appropriate positioning of the probe.
The medial and lateral menisci appear
as homogeneously triangular areas on
longitudinal scans with their apices
centred on the articular rim.

Tendons
The quadriiceps and patellar tendons
have characteristic “fibrillar” echotext-
ure and are clearly delimited from the
surrounded tissues by sharp hyperecho-
ico margins corresponding to the peri-
tenon. Neither tendon has a tendon
sheath. The anatomical margins of the
quadriiceps tendon are clearly defined
with soft tissue delimiting the anterior
and the supra-patellar fat pad the poste-
rior margins. The US features of the
patellar tendon include more expanded
transverse diameter at the proximal in-
sertion compared to the tibial insertion.
Both the patellar and tibial insertions
demonstrate the typical features of an
enthesis.

Bursae
Synovial bursae of the knee are not
detectable in healthy subjects. The
superficial bursae are virtual cavities
which are not in communication with
the knee joint. The suprapatellar bursa
is located deep to the quadriiceps ten-
don and is in direct communication
with the knee joint. The prepatellar bursa
lies anterior to the lower pole of the
patella and the origin of the patellar
tendon. In the infrapatellar region there
are two anatomically important bursae:
superficial and deep with the tibial
bubercle acting as the US landmark for
identification. The pes anserine bursa
represents one of the most clinically
relevant bursae around the knee. It is
located on the antero-medial aspect of
the tibia and is found between the ten-
dons of semi-tendinosus, gracilis and sar-
torius. The gastrocnemius-semimembran-
osus bursa communicates with the knee
joint cavity and may enlarge with knee
joint effusions.

US pathology

Joints
Joint effusion represents one of the ear-
liest clinical signs of synovial patholo-
gy within the knee joint. Its hallmark
features include distension of the artic-
ular recesses within the knee joint with
joint fluid of differing degrees of
echogenicity. US is a particularly use-
ful scanning modality to confirm the
presence of effusion and document the
presence of synovial hypertrophy and
hypervascularity using power Doppler.
There is compelling scientific evidence
to support the superiority of US over
clinical examination in detecting the
presence of a knee effusion (8).
Moreover, highly positive correlation
has been demonstrated in the assess-
ment of synovial tissue vascularity of
the knee in patients with osteoarthritis
and rheumatoid arthritis between
power Doppler sonography and histo-

Table I. Main indications for performing an US examination of the knee.

<table>
<thead>
<tr>
<th>Indications for performing US examination.</th>
<th>US pathology</th>
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<tbody>
<tr>
<td>Detect synovitis (especially sub clinical knee inflammation).</td>
<td>Rheumatological setting</td>
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<tr>
<td>Reveal femoral cartilage involvement.</td>
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<tr>
<td>Guide intra-articular injection of hyaluronic acid.</td>
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<tr>
<td>Detect synovitis (especially sub clinical knee inflammation).</td>
<td>Rheumatoid arthritis</td>
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<td>Assess pannus vascularity.</td>
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<tr>
<td>Reveal cartilage and bone lesions.</td>
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<td>Assess entheseal involvement.</td>
<td>Seronegative spondyloarthropathies</td>
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<tr>
<td>Detect synovitis (especially sub clinical knee inflammation).</td>
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</table>
| Identify crystal aggregates within or on the surface of the cartil-
gage layer. | Crystal related arthropaties |
| Guide aspiration of even small amounts of fluid for subsequent
synovial fluid analysis. | | |
| Assess the morphostructural integrity of the assessable anatom-
ic structures of the knee and identify characteristic pathologic
changes eg. jumper’s knee and Osgood-Schlatter disease. | Knee pain |
| Detect popliteal cyst and its topographic relationship with the
popliteal vessels. | Pseudo thromboembolits |

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pathologic evaluations (12, 13).

Furthermore, various anatomical details within the effusion can provide the rheumatologist with further important information pertinent to making the final clinical diagnosis eg. the presence of crystalline matter, rice bodies etc. There has been growing interest in the appearance of articular cartilage of the knee in various arthropathies, particularly OA. A spectrum of change has been described within the femoral cartilage particularly in the medial compartment of the tibio-femoral joint including focal thinning, loss of sharpness of the superior cartilagenous margin and eventual denuded areas. High frequency US has been used successfully in the quantitative assessment of degenerative changes in knee OA (16-21).

Tendons
US is regarded as the gold standard imaging modality for the assessment of the tendons (29-31). At knee level, US permits accurate and detailed morpho-structural analysis of the tendons. Several sonographic abnormalities of quadriceps and patellar tendon echotexture can be documented including anechoic discontinuity of the “fibrillar” pattern, hypoechoic areas within the tendon, hyperechoic spots without acoustic shadow and hyperechoic bands which may generate acoustic shadow. The specific US findings and their distribution within the tendon are helpful for understanding the underlying pathology. In subjects with jumper’s knee for example, the proximal and deeper part of the patellar tendon is typically involved (32-34). In patients with Osgood Schlatter disease, US may detect a wide range of pathologic findings including soft tissue oedema, fragmentation of the ossified centre at the anterior tibial tubercle, thickening of the distal part of the patellar tendon and deep infrapatellar bursitis (35). In routine rheumatological practice the major tendons around the knee joint are the focus of attention in cases where enthesopathy is suspected. As in other anatomical areas, enthesopathy of the quadriceps and patellar tendons may show the following pathologic features: loss of normal fibrillar echotexture (with or without Doppler signal) and/or thickening of the tendon at its bony attachment and/or changes of the bone profile including enthesophytes, erosions or irregularity (36).

Bursae
Bursitis most often represents a primary inflammatory process depending on the specific bursa affected. Some bursae communicate with the knee joint and secondarily become involved in the inflammatory process. Pes anserine bursitis is a common clinical problem, particularly in knee OA and with US appears as a cystic area adjacent to the pes anserine tendon. It may develop into a chronic condition with synovial hypertrophy filling the bursal space and focal calcification.

With US, prepatellar and infrapatellar bursitis can be readily identified both by reproduction of pain upon sonopalpation over the area and by the rather flattened hypoechoic sac seen. Great care must be taken while performing US to prevent excessive pressure and therefore apparent collapse of these small distended bursal sacs.

One of the first pathological findings to be described by US in rheumatology was a popliteal or Baker’s cyst. These are synovially lined cysts and represent distended gastrocnemius-semimembranosus bursae filled with hypoechoic fluid and occasionally containing septae and loose bodies. The US confirmation of a popliteal cyst is made by identification of the neck which is located between the semimembranous tendon and the medial gastrocnemius muscle.

Sonographic guided procedures
US is particularly useful in guiding injections of the knee joint because it permits direct visualization of the needle into the joint cavity and ensures accurate delivery of the intra-articular substance injected.

This confirmation of correct placement of the tip of the needle within the joint space is particularly useful for hyaluronic acid injection into a “dry” knee. US is of tremendous help when soft tiss-
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Controversial issues

At present the role of US in reliably performing quantitative measurements of articular cartilage thickness in degenerative arthropathies is perhaps one of the most stimulating areas of debate within rheumatology and musculoskeletal radiology. An expanding body of scientific knowledge is being developed in this area with several reporting very encouraging results (16, 17, 19-25).

Link

For further ultrasound images, go to: www.clinexpreumatologo.ultrasound

References

23. ADLER RS, DEDRICK DK, LAING TJ et al.: