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EXAMINATION TECHNIQUE

An ultrasound examination of the musculoskeletal system does not require any preparation and has no contraindications. It should follow some important rules regarding:

1. Choice of transducer
2. Patient position
3. Ultrasound examination

1. **Choice of transducer**
   A high frequency linear array is mandatory. The use of high frequencies (18-6 MHz) provides exquisite image resolution (Fig. 1), often better than with MRI. Small transducers, formed like a hockey stick, are available and are best suited for examination of the superficial structures of the wrist/hand or ankle/foot (Figs. 2). If a higher penetration is requested (obese or athletic patient, examination of menisci in the knee or anterior glenoid labrum in the shoulder), a lower frequency is preferable.

   A linear array provides a large field of view in the near-field zone, but cannot give the same overview that is available with computed tomography or MRI. The most important advantage of a linear array is that the ultrasound beams are all parallel, and can all be oriented at the same time perpendicular to the reflective structures of the soft tissues (e.g. tendons and muscles), thus avoiding the anisotropic artifact (see sub section 3, “Ultrasound Examination”).

   **Fig. 1.** High frequency linear array transducers.

   **Fig. 2a.** Very high frequency linear array transducer, Hockey Stick transducer 8809, (15-6 MHz) for examination of very superficial structures (wrist/hand and ankle/foot).

   **Fig. 2b.** Hockey Stick transducer 8809 equipped with needle guide.
2. Patient position
Patient position depends on the examined region—supine for the quadriceps tendon, the patellar tendon or the anterior recess of the hip; prone for the popliteal fossa, for the Achilles tendon or the plantar fascia; seated for the rotator cuff of the shoulder (Fig. 3a). A small cuff can be placed under the knee or ankle to straighten the fibers of the extensor mechanism of the knee or the Achilles tendon. Internal rotation of the shoulder with the arm behind the back has same effect on the supraspinatus tendon.

Fig. 3a. Ultrasound examination of the shoulder with the patient seated.

Fig. 3b. Corresponding normal transverse view of the long head of the biceps in the bicipital groove.

Fig. 3c. Transverse view of the bicipital groove in a patient with effusion in the bicipital tendon sheath.

3. Ultrasound examination

Perpendicular examination. One should always examine most musculoskeletal structures (tendons, ligaments, muscles and menisci) perpendicularly, to provide strong reflections and good visualization of the anatomical details. This is important to differentiate true pathology from the anisotropic artifact, which appears when anatomical structures are examined with a certain angle and are falsely hypoechoic (Fig. 4).

Comparison with the contralateral side. Examine the opposite limb as a reference if there is any doubt about the ultrasound findings. The split-screen facility makes it easier to compare subtle differences in size, form or echogenicity between both sides (Fig. 5).

Interaction with the clinical findings. One of the important advantages of ultrasonography is the direct interaction with the clinical examination (symptoms and palpation findings).

Sonopalpation. Compression with the transducer may provide information about the structure (fluid vs. solid) and elasticity (malignant tumor or fibrosis vs. benign tumor or fat) of the soft tissues. Remember that the use of a large amount of gel and minimal pressure (or no contact between transducer and skin) may be important to visualize very superficial soft structures, as they may “disappear” when examined with too much compression (bursitis, tenosynovitis).

Color Doppler examination. Detection of soft tissue vessels makes it possible to differentiate between solid tissue and fluid, and to identify regions that may represent inflammation (Fig. 6), tissue regeneration or tumors.

Dynamic examination. Use scanning during active mobilization of the soft tissues whenever it may provide additional information. This is also one of the strengths of ultrasonography. The physiological information thus obtained makes it easier to recognize anatomical structures and to situate the position, extension and boundaries of pathological changes. Dynamic tests may help the visualization of small tendon or muscle tears, muscle hernias, tendon subluxation, glenoid labrum lesions, shoulder impingement and joint instability.

Ultrasound-guided interventional procedures. Ultrasonography provides “real-time” images and is ideal for the guidance of interventional procedures. When needed, they should be an integral part of the ultrasound examination. Using a needle guide (Fig. 2b) or free-hand, the following diagnostic and therapeutic procedures may be performed:

- evacuation of fluid collections (abscess, hematoma, serma, bursitis, cyst and joint effusion) by puncture or catheter drainage
• needle biopsies (soft tissue tumor, enlarged lymph node, suspected recurrence in patients with operated sarcoma). Steroid injection (joint, tendon sheath or bursa)
• aspiration of tendon calcification
• preoperative needle localization of non-palpable pathological findings
• removal of foreign body
• intraarticular injection of contrast (arthrography)

Follow-up. Ultrasonography is relatively cheap and widely available, quick and easy to perform, well tolerated and radiation free. Ultrasonography is therefore valuable to follow patients with sports injury, to control drained fluid collections, for diagnosing postoperative complications after joint replacement or treatment with osteosynthesis, and for detecting recurrences of malignant diseases.

ULTRASONOGRAPHY OF NORMAL ANATOMICAL STRUCTURES

1. Tendons, tendon sheaths and bursae
Normal tendons have a hyperechoic tight fibrillar structure on longitudinal scanning planes with the ultrasound beam perpendicular to the tendon (avoiding the anisotropic artifact) (Figs. 4).

On perpendicular transversal scanning planes, tendons are filled with bright echoes. Tendons are either surrounded by a synovial tendon sheath (very thin hypoechoic rim around the tendon as the synovial cavity is virtual) or by a peritendon (thin hyperechoic layer). There is very little or no intratendinous flow on the color Doppler examination. At bone insertions, meticulous examination perpendicular to the tendon fibers often reveals a thin fibrocartilaginous hypoechoic layer between tendon and bone. Tendons move freely during the dynamic examination.

Some synovial bursae are demonstrable when normal. The subdeltoid-subacromial bursa is seen as a thin hypoechoic layer between the deltoid muscle and the rotator cuff. The deep infrapatellar bursa and the retrocalcaneal bursa are seen as small, triangular, anechoic structures.

2. Joints
Ultrasonographic detection of the normal synovial membrane is not possible. Synovial recesses with a minimal amount of fluid are nevertheless often seen as thin hypoechoic structures in relation to joint lines. Cartilage and menisci may be assessed in certain areas (not covered by bone). Cartilage is seen as a hypoechoic band overlying the bone, with a smooth thin hyperechoic surface. The menisci in the knee and the glenoid labrum in the shoulder or hip are seen as triangular homogeneously hyperechoic structures (fibrocartilage). Ligaments are seen as hyperechoic fibrillar structures, similar to tendons, bridging over the joint lines. The medial collateral ligament of the knee is about nine cm long, and has a trilaminar structure: superficial (hyperechoic and fibrillar); intermediate (nonfibrillar fibroadipous heterogeneous, hyperechoic or hypoechoic); deep (hyperechoic and fibrillar, adherent to the medial meniscus). Stress tests may give information about the stability of joints.
3. Muscles
On longitudinal scanning planes, muscles have a hypoechoic background with fine and parallel hyperechoic lines (interfibrillar fibroadipous septa or perimysium). The orientation of these septae is typical and different types of muscles are described (longitudinal, unipennate, bipennate, circumpennate) (Fig. 7a). On transversal scanning planes, the hypoechoic background is dotted with fine echoes and sometimes a few hyperechoic septae (Fig. 7b). The more pronounced hyperechoic boundary around the muscle is the muscle aponeurosis. Vessels (anechoic tubular structures) and nerves (fascicular tubular structure) are visualized in and between muscles.

4. Nerves
Nerves have a fascicular structure, which is less echogenic than the fibrillar structure of tendons (hypoechoic fascicle in a hyperechoic connective stroma) (Fig. 8).

5. Bone
Intraosseous structure and changes cannot be assessed, but the bony surface is easy to analyze and is seen as relatively regular, hyperechoic, with strong shadowing.

6. Fat
Fat has a typical aspect: hypoechoic background with thin hyperechoic linear septae oriented in different directions. The overall echostructure is therefore heterogeneous and generally hypoechoic.

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**Fig. 6.** Longitudinal color Doppler examination of an active tenosynovitis of the extensor digitorum longus tendons at the wrist, showing hyperemia in tendons and tendon sheath.

**Fig. 7a.** Normal brachioradialis muscle at the forearm. Longitudinal view.

**Fig. 7b.** Normal brachioradialis muscle at the forearm. Transversal view.

**Fig. 8.** Normal aspect of the right carpal tunnel at the wrist. Transversal scanning of the anterior wrist. Corresponding drawing.
(but may be relatively hyperechoic), and the anisotropic artifact is low or absent. The main fatty areas are the subcutaneous fat, Kager’s triangle (between the ankle and the Achilles tendon) and the intra-articular (intracapsular and extrasynovial) fat pads of the anterior knee (Hoffa’s fat pad behind the patellar ligament), the anterior and posterior elbow and the anterior ankle.

7. Skin
The skin is a thin, hyperechoic and homogeneous layer.

PATHOLOGY
Ultrasoundography has been largely used for the examination of tendons, tendon sheaths and bursae. Due to the improved capability of ultrasonography to demonstrate even small anatomical structures, there is now a wider range of indications, mainly in sports injuries, rheumatic diseases and patients with palpable masses in the soft tissues.

1. Tendons, tendon sheaths and bursae
Tendon overuse may lead to tendinopathy which is mostly a chronic condition with impaired tendon repair. Ultrasonography shows an enlarged and diffusely hypoechoic tendon. Peritendinous and intratendinous hypervascularization is often displayed on color Doppler examination. Intratendinous calcifications are rare and generally seen as bright reflective structures without through-transmission (strong posterior shadowing). Findings may also be focal, e.g. in the upper insertion of the patellar tendon (jumper’s knee).

Peritendinitis is an inflammatory reaction in the peritendon and sometimes seen as a hypoechoic layer in contact with a tendon that do not have a tendon sheath (e.g. the Achilles tendon). Tenosynovitis is an inflammation of a tendon sheath, which is filled with fluid (anechoic) or synovial tissue (hypoechoic), and best seen on a transverse scans. Synovial hypervascularization may be detected on a color Doppler examination. A subacute type of tenosynovitis may be seen in osteofibrous tunnels where tendons can be compressed. A typical example is de Quervain’s stenosing tenosynovitis on the radial aspect of the wrist, where ultrasound shows hypertrophy of the tendon retinaculum (often with hyperemia).

Tendon tears should be diagnosed without delay and are seen as a defect in the substance and/or the outline of a tendon. Small changes may be difficult to describe, when tears develop in tendons with previous degenerative lesions (tendinosis). It is important to differentiate between small intratendinous microruptures (which are not functional), partial tendon tears and complete tendon tears. Partial tears often produce a defect in the outline of the tendon. Partial tears in tendons surrounded by a tendon sheath often progress into a longitudinal
splitting of the tendon, which may also be hypertrophied (e.g. peroneus tendons at the ankle). In complete transversal tears, a retraction of the tendon fragments is often present and should be measured in order to plan the surgical treatment. In difficult cases, the retraction may be detected or induced by a dynamic examination.

Tears may also be localized at the bony insertion (with or without bony avulsion) or at the musculotendinous junction (e.g. the tennis leg, which is a tear of the insertion of the Achilles tendon on the medial gastrocnemius muscle, and diagnosed indirectly by an anechoic/hypoechoic blood collection localized between the medial gastrocnemius and soleus muscles).

Bursitis is detected as a fluid-filled or synovial flat structure in characteristic anatomical sites. Small amounts of fluid may be overlooked if the examination is performed with too much compression. On a seated patient, small amounts of fluid in the large subdeltoid bursa should be searched for in certain locations (anterior, lateral/distal, or under the coraco-acromial ligament).

2. Shoulder
Symptoms of shoulder joint pathology can be related to a large number of causes (periarticular, articular, osseous), but most patients with shoulder pain have a disease of the periarticular soft tissues (rotator cuff, long head of the biceps and subdeltoid-subacromial bursa). Ultrasonography has therefore shown to be an outstanding first line examination modality.

Rotator cuff pathology (subscapularis, supraspinatus and infraspinatus tendons) may be acute tendinitis, degenerative tendinopathy, tendon tears, or intratendinous calcifications. Tendinopathy and tendon tears are most frequently found in the supraspinatus tendon (Figs. 5 and 9), which is due to the exposed anatomical position of this tendon during abduction (subacromial impingement). It should be kept in mind that degenerative changes are commonly present in the supraspinatus tendon and increase with age. Supraspinatus tendon tears can be full-thickness tears (with communication between the shoulder joint and the subacromial-subdeltoid bursa) or partial-thickness tears (of the deep or superficial part of the tendon) (Figs. 9). They should be localized and measured in two directions. Muscle atrophy and/fat degeneration should be described.

Intratendinous calcifications may be symptomatic (pain, impingement) and are mostly found in the supraspinatus tendon and seen as hyperechoic with a strong posterior shadowing when hard (Figs. 9), or less reflective without a posterior shadowing when smooth. Calcifications may be treated by ultrasound-guided needle aspiration.

Dynamic ultrasound examination of the shoulder is of great value and may objectively show pathological conditions like subacromial impingement (painful arc during compression of the supraspinatus tendon and subacromial bursa against the coracoacromial arch during abduction of the arm).

Pathology of the long head of the biceps: Effusion in the tendon sheath is not necessarily a sign of tenosynovitis as it is related to shoulder joint effusion (communication between the joint and the tendon sheath) (Figs. 3). Changes in the tendon may be due to tendinosis (thick hypoechoic tendon, sometimes...
with inflammation of the tendon sheath), partial tendon tear (sometimes with splitting of the tendon) or complete tendon tear (empty bicipital groove, retracted distal tendon part, if chronic atrophic hyperechoic muscle). Luxation of the long head of the biceps is clinically difficult to diagnose but easy to detect ultrasonographically (empty bicipital groove with medially located tendon).

Subdeltoid-subacromial bursa (Figs. 10): fluid in the bursa and/or thickness of the synovial wall over the supraspinatus tendon (site of impingement). In inflammatory joint diseases, bursitis is often evident, with marked hypoechoic synovial hypertrophy and hyperemia. Treatment by steroid injection in the bursa may be safely and efficiently performed with ultrasound-guidance (Fig. 11).

Diseases of the acromio-clavicular joint may mimic diseases of the rotator cuff (osteoarthritis, arthritis, luxation) and should always be searched for (Figs. 12).

In patients with a direct shoulder trauma, ultrasonography may differentiate between rotator cuff tear, rotator cuff tendinitis, subdeltoid-subacromial bursitis, fracture of the greater tuberosity (which may be missed on plain radiography), ligament lesions of the acromio-clavicular joint (with or without luxation).

3. Knee
MRI is an established imaging technique, which provides a complete examination of the knee. Ultrasonography is unsurpassed for the assessment of the periarticular soft tissues (tendons, bursae, collateral ligaments, patellar retinaculum), but evaluation of the important intraarticular structures of the knee (menisci and cruciate ligaments) is incomplete as compared to MRI.

Signs of joint effusion and/or synovitis are searched for in the suprapatellar recess (Figs. 13). If there is any doubt in differentiating these findings, compression of the recess with the transducer is easy to perform. Bony, or even radio-negative cartilaginous loose bodies may be detected in joint recesses or in a Baker’s cyst.

In the extensor mechanism of the knee signs of tendinopathy can be found in the patellar or the quadriceps tendon. The so-called “jumper’s knee” is a focal tendinopathy, with a hypoechoic area in the deep part of the upper insertion of the patellar tendon (Figs. 14). This lesion is often hypervascularized on the color Doppler examination and calcifications are frequently developing. Tendon tears are mostly seen in the distal part of the quadriceps tendon, about one or two cm from the bony insertion.

In “runner’s knee”, an overuse condition in runners with antero-lateral knee pain, ultrasonography may show a hypoechoic
mass (bursa) between the iliotibial band and the lateral femoral condyle.

The iliotibial band may be thickened at the level of the femoral condyle or at the tibial insertion.

Masses around the knee may be Baker’s cysts (pathological distension of the semimembranosus-medial gastrocnemius bursa), bursitis (most commonly prepatellar or infrapatellar), ganglion cysts (generally anechoic, in relation to the knee joint capsule or the superior tibiofibular joint, and containing a thick, gelatinous material when aspirated), meniscal cysts (generally communicating with a meniscal tear), hematomas, abscesses, and soft tissue tumors.

In patients with a mass in the popliteal fossa, Baker’s cysts, tumors, popliteal aneurysms and hematomas may be identified properly. Baker’s cysts are identifiable on their location and visualization of the communication between the cyst and the knee joint (Figs. 15). In patients with an acute edematous leg, differentiation between a Baker’s cyst rupture with the presence of subfascial fluid in the leg, and venous or thrombosis (Fig. 16) may be obtained.

MRI is still the golden standard for the demonstration of meniscal lesions, but ultrasonography may detect a great number of them, especially in the posterior horn of the medial meniscus. This posterior horn is particularly well demonstrated using a posterior approach and a dynamic examination (flexion/extension of the leg). Lesions are seen either as hyperechoic lines or - if the meniscus fragments are displaced - as hypoechoic/anechoic clefts.

Lesions of the collateral ligaments are easy to diagnose, but lesions of the cruciate ligaments are best demonstrated by MRI. Nevertheless, an acute lesion of the anterior cruciate ligament may be detected indirectly by the presence of a hematoma at the upper, femoral insertion of the ligament in the intercondylar fossa.

Other lesions that may be displayed are lesions of the medial patellar retinaculum (acute or chronic patella instability) or signs of Osgood-Schlatter disease (cartilage thickening and bony fragmentation in the tibial tuberosity, patellar tendinitis and infrapatellar bursitis) (Figs. 17).

4. Ankle and foot

Ultrasonography is frequently performed to demonstrate Achilles tendon diseases. The symptoms may be due to tendinopathy, peritendinitis, tendon rupture, enthesopathy or retrocalcaneal bursitis.

In tendinopathy, a diffuse or focal hypoechoic tendon thickening with preservation of the fibrillar tendon structure is found. The tendon is rounded on a transverse scanning plane, with a convex anterior border and an anteroposterior diameter over 6 mm. On color Doppler examination, intratendinous hyperemia is often present, with anterior feeding vessels. Microruptures and calcifications may develop. Peritendinitis is seen as a hypoechoic thickening of the peritendon, with or without signs of tendinopathy.

Signs of enthesopathy of the Achilles tendon may be seen at the insertion on the distal part of the posterior surface of the calcaneus in patients with overuse or inflammatory joint
diseases. In Haglund’s disease, two signs are seen on ultrasound: a retrocalcaneal bursitis (enlarged, fluid or synovial filled bursa in the angle between the Achilles tendon and the calcaneus, sometimes with an elongated partial tendon tear. The third element of the diagnostic triad (hypertrophy of the posterosuperior calcaneus) is best seen on standard radiography or MRI.

Achilles tendon tears (partial or complete) generally occurs in tendons with underlying tendinopathy, generally 5 to 6 cm from the insertion on the calcaneus. In complete tears, tendon retraction is measured, which may help for the treatment decision (surgical or not). The tendon defect may be filled with fluid, blood, invaginated fat or, when chronic, granulation tissue. A dynamic examination is very useful in difficult cases (e.g. postoperative reruptures).

In “tennis leg”, a partial tear is localized at the distal musculotendinous junction of the medial gastrocnemius muscle. A fluid collection is detected between the medial gastrocnemius and soleus muscles. Over time, a hypoechoic fibrous residual mass may develop.

Anterior, lateral or medial tendons have tendon sheaths and ultrasonography is outstanding for the demonstration of tenosynovitis, tendon tear or tendon instability. In tenosynovitis, there is fluid and/or synovial proliferation in the tendon sheath. In partial tendon tear, a longitudinal split of the tendon may develop (most frequently in the peroneus brevis or tibialis posterior tendons). In complete transversal tendon tear, the exact extend of the tendon retraction is visualized. Color Doppler is used to detect vascular activity, and ultrasound-guidance for needed interventional procedures. Ultrasonography may show instability of the peroneus tendons over the edge of the lateral malleolus. A dynamic test (eversion/dorsal flexion of the foot) may be necessary to detect difficult cases.

Signs of joint effusion, synovitis and/or loose bodies are detectable in the anterior, lateral or medial recesses, but the posterior recess is more difficult to analyze.

Ligament lesions (anterior talofibular, calcaneofibular, anterior tibiofibular or medial collateral ligaments) may be detected, especially in patients with chronic problems (e.g. anterolateral “impingement” due to granulomatous tissue at the anterolateral joint line).

Diseases of the plantar fascia are easy to demonstrate by ultrasonography: Plantar fasciitis (thickened and hypoechoic calcaneal insertion) (Figs. 18); tear (several cm distal to the calcaneus); plantar fibromatosis (hard hypoechoic nodules in the distal plantar fascia) (Fig. 19).

Morton’s neuroma is a fibrotic pseudotumoral lesion of the plantar interdigital nerve, most frequently seen in the 3rd or 2nd interstitium. On ultrasonography, a small, hypoechoic mass with irregular margins is found between the metatarsal heads (Fig. 20).

5. Hip
Most ultrasonographic examinations of the hip are performed to detect signs of synovitis (joint effusion and/or synovial hypertrophy) and to perform ultrasound-guided needle puncture when infectious or cristal arthropathy is suspected. Intra-articular steroid injection may also be performed by the same
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6. Wrist and hand

Most tendons around the wrist have a tendon sheath. Tendon synovitis may easily be diagnosed by ultrasonography. Most frequent is de Quervain’s tenosynovitis, which is a subacute stenosing tenosynovitis related to overuse and thickening of the retinaculum of the 1st dorsal compartment. Flexor tendon tenosynovitis may lead to carpal tunnel syndrome. In patients with infection, ultrasonography may detect infectious tenosynovitis or foreign bodies. Ultrasound-guided puncture may be performed for aspiration when infection is suspected, or steroid injection when infection is ruled out.

Tendon rupture is also well demonstrated, and the level of the retracted proximal tendon communicated to the surgeon. Dynamic tests may help to detect tendon instability (extensor carpi ulnaris).

Signs of tendinopathy and enthesopathy are seen in tendons without tendon sheath (flexor carpi ulnaris).

Effusion, synovitis and/or bone erosions of the wrist, carpal joints or finger joints are important findings in inflammatory joint diseases (e.g. rheumatoid arthritis).

In carpal tunnel syndrome, entrapment of the median nerve is directly visualized (thickening proximal to the flexor retinaculum, flattening at the level of the retinaculum and bulging of the retinaculum). The cause of an extrinsic compression may be detected (e.g. ganglion cyst, flexor tendon tenosynovitis, wrist synovitis).

Masses around the wrist, most frequently ganglion cysts, may be examined. Ganglions are generally anechoic lesions connected to joint lines or tendon sheaths. MRI should be performed in all suspicious masses.

Some ligament lesions of the wrist and fingers may benefit from ultrasonography. Lesion of the ulnar collateral ligament of the first metacarpophalangeal joint (skiers’ thumb) may lead to chronic instability of the thumb if untreated. Surgery is mandatory if the proximal part of the ligament is luxated dorsally to the adductor fascia (Stener’s lesion), which is seen on an ultrasound as a small hypoechoic mass.

7. Elbow

Ultrasonography of the synovial recesses (anterior, posterior and annular at the radial neck) may show signs of joint effusion, synovitis or loose bodies (sometimes radio-negative).

The biceps tendon is a difficult structure to examine, due to its obliquity at the insertion on the radial tuberosity. Complete tear of the biceps tendon is not always clinically evident as retraction of the tendon and muscle may be prevented if the lacertus fibrosus is intact. Ultrasonography may be helpful in

**Fig. 15b.** Left Baker’s cyst. Longitudinal view.

**Fig. 15c.** Left Baker’s cyst. Ultrasound-guided puncture for steroid injection.

**Fig. 16.** Thrombosis of a medial gastrocnemius muscle vein (longitudinal color Doppler view).
these cases and differentiate between biceps tendinopathy, complete or partial tear, and bicipitoradial bursitis. Lesions of the triceps tendon are not frequent. Olecranon bursitis are easy to document but generally clinically evident.

Ultrasonographic signs of inflammation of the tendon insertion at the lateral (tennis elbow) and medial (golfer elbow) humeral epicondyle are those seen in all types of enthesopathy (hy- poechoic tendon thickening, microruptures, calcifications, bone irregularities and/or hyperemia) (Figs. 21).

8. Joint diseases
Ultrasonography of joints cannot provide a full examination of all anatomical areas, but most joint diseases (e.g. inflammatory, degenerative or tumoral joint diseases) are associated with changes in the synovial recesses, which are often accessible to the ultrasonographic examination. Patients with joint inflammation develop non-specific signs of joint effusion, synovial thickening, and/or synovial hyperemia.

Joint effusion is easy to detect by ultrasonography, which is helpful when the clinical examination is difficult (hip). Even a small amount of fluid may be detected. Certain recesses are predominantly involved (anterior recess in the hip and the ankle, suprapatellar recess in the knee, tendon sheath of the long head of the biceps in the shoulder). Ultrasound guided needle aspiration of the joint fluid may lead to an immediate release of the pain (in patients with high intracapsular pressure), and provide the diagnosis in septic or cristal arthritis.

Synoval thickening may be seen directly on ultrasonography and measured precisely: thick hypoechoic synovial tissue connected with the joint line, sometimes with villous formations or a pseudotumoral aspect (rheumatoid pannus). Differentiation between effusion and synovitis may be made by compression with the transducer (suprapatellar recess), color Doppler examination (synovial hyperemia), or ultrasound-guided puncture. Bone destruction may be found (tumor, rheumatoid arthritis). Cartilaginous changes in patients with arthritis or osteoarthritis may be detected in regions available to ultrasonography (not covered by bone): heterogeneous echostructure, irregular surface, focal defect or a thinning of the cartilage.

9. Muscles
Ultrasonography is useful in traumatic pathology. The real extension of a lesion is best studied after a couple of days. Contusions (hyperechoic areas) and partial/complete tears (localized blood collections) may be diagnosed (Figs. 22). In difficult cases, a dynamic examination may be helpful. Bacterial infection may lead to pyomyositis and abscess (collection). Ultrasound guided needle puncture of even small fluid collections provides immediate and safe detection of abscesses (pus).

The microbiological diagnosis of abscesses may be obtained without delay, and ultrasound may guide catheter drainage.

Ultrasonography may give information about the localization, size and anatomical relations of soft tissue tumors, but cannot make a definite diagnosis of malignancy or benignity. Some tumors may nevertheless be relatively easy to recognize, e.g. lipomas (Figs. 23), hemangiomas, neurinomas, or some sarcomas. A preoperative histologic diagnosis is often necessary and should be planned when all diagnostic imaging (MRI) is performed. In many centers, it is obtained as an
ultrasound-guided needle biopsy, which is less traumatic than an open surgical biopsy.

Ultrasonography is a very reliable technique for the detection of foreign bodies in the soft tissues (hyperechoic structure, with or without shadowing, sometimes surrounded by hypoechoic tissue). Removal may be performed ultrasound-guided.

10. Nerves
Some soft tissue masses arise from or connect tightly to a nerve (neurinomas, neurofibromas, neuromas, ganglion cysts). This connection may be displayed by ultrasonography.

In patients with nerve entrapment - carpal tunnel syndrome (median nerve), cubital tunnel syndrome (ulnar nerve at the elbow), Guyon tunnel syndrome (ulnar nerve at the wrist), common peroneal nerve at the fibular neck, tarsal tunnel syndrome (tibial nerve), intermetatarsal space (Morton’s neuroma) - nerve compression can be seen and an extrinsic cause may be found: tenosynovitis, synovitis, ganglion cyst, soft tissue tumor, osteophyte, foreign body.

Instability of the ulnar nerve may be assessed dynamically during flexion of the elbow.

11. Bones
Changes that affect the bone surface are detectable by ultrasonography: fractures (Fig. 24), exostoses, destructions in patients with bone metastases or rheumatoid arthritis, osteomyelitis with subperiosteal abscess formation.

CONCLUSION
BK Medical provides a number of high frequency linear array transducers that are optimized for intraoperative vascular surgery and musculoskeletal applications. For physicians the benefits are high-resolution imaging with good penetration during near-field small-part scanning at a reasonable price.

Transducers from BK Medical can perform dynamic ultrasound examinations; they are equipped with high Doppler sensitivity and are optimized for steered Doppler examination.

Interventional procedures, such as biopsies and therapeutic applications, are made easy and straightforward.

Physicians can see even small structures, such as those in the hand and wrist, with exceptional clarity. Transducers from BK Medical exploit the resolution of very high frequencies so that the contrast and resolution they provide are excellent for detailed examinations, where the ability to detect small structures is crucial (Figs. 1 and 2).

Fig. 18b. Fasciitis plantaris. Normal left longitudinal view.

Fig. 18c. Fasciitis plantaris. Right transversal view during ultrasound-guided steroid injection with the tip of the needle just deep to the proximal aponeurosis.

Fig. 19. Plantar fibromatosis. Two hard hypoechoic nodules in the mid plantar aponeurosis (longitudinal view).
**Fig. 20a.** Morton’s neuroma of the 3rd interdigital space (dorsal longitudinal views). Focal hypoechoic, hard process with irregular borders connected distally to the plantar digital nerve.

**Fig. 20b.** Morton’s neuroma of the 3rd interdigital space (dorsal longitudinal views). Ultrasound-guided steroid injection with the tip of the needle in contact with the neuroma.

**Fig. 21a.** Tennis elbow. Longitudinal views over the lateral humeral epicondyle. Hypoechoic thickening of the common tendon insertion.

**Fig. 21b.** Tennis elbow. Longitudinal views over the lateral humeral epicondyle. Hyperemia on color Doppler examination.

**Fig. 22a.** Two months old partial tear of the rectus femoris muscle. Longitudinal view.

**Fig. 22b.** Two months old partial tear of the rectus femoris muscle. Transversal view.

**Fig. 23a.** Subcutaneous lipoma at the shoulder, covering the acromion. Isoechoic focal mass with intratumoral septae (fat).

**Fig. 23b.** Subcutaneous lipoma at the shoulder, covering the acromion. No vascularization on color Doppler examination.

**Fig. 24.** Impaction fracture of the greater tuberosity with irregular bony surface (transversal view).