UPDATE

Ultrasound-guided interventional procedures in the musculoskeletal system

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Abstract

Ultrasoundography is the most appropriate tool for interventional procedures in the musculoskeletal system when the lesion is visible on ultrasonography. Procedures performed under ultrasonographic guidance include: taking biopsies; draining abscesses; bursitis; hematomas or muscle tears; treating cystic lesions; diagnostic or therapeutic arthrocentesis; injecting substances into joints or lesions; aspirating calcium deposits and extracting foreign bodies. Although some of these procedures are often carried out without imaging guidance, ultrasonographic guidance improves their efficacy. Drainage can be performed with catheters or needles and makes it possible to avoid more aggressive treatments in most cases. Urokinase is useful for draining hematomas or fibrinous collections. Injecting corticoids is useful in the treatment of synovial cysts, Baker’s cyst, tendinitis, and non-infective arthritis. Calcifying tendinitis of the shoulder can be treated effectively with percutaneous calcium lavage.

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KEYWORDS
Musculoskeletal system; Ultrasonography; Interventional procedures; Drain; Tendinitis; Arthrocentesis

PALABRAS CLAVE
Sistema musculoesquelético; Ecografía; Intervencionista; Drenaje; Tendinitis; Arthrocentesis

Intervencionismo guiado por ecografía en el sistema musculoesquelético

Resumen

La ecografía es la herramienta más adecuada para la realización de procedimientos intervencionistas en el sistema musculoesquelético (SME) si la lesión es visible ecográficamente. Estas técnicas incluyen: biopsias, drenaje de abscesos, bursitis, hematomas o roturas musculares, tratamiento de lesiones quísticas, arthrocentesis diagnóstica o terapéutica, inyección de sustancias en articulaciones o lesiones, aspiración de depósitos cálcicos y extracción de cuerpos extraños.

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Ultrasound (US) is an excellent technique for the detection, localization and identification of a wide range of lesions of the musculoskeletal system (MSS). US is also the most appropriate tool for interventional procedures in the MSS when lesions are visible on US. Advantages and limitations of US have been analyzed in a previous article.

There are numerous procedures that may be performed in the MSS with US guidance (table 1). The technique and general requirements of these procedures have been previously described; however, when used in the MSS, these techniques show some particularities worthy of consideration:

- **Transducers.** High resolution (> 7 MHz) linear array transducers are ideal for interventional procedures in the MSS. Nonetheless, a curved array probe with lower frequency may be needed for deep lesions. A disadvantage of curved probes is anisotropy that makes needle visualization more difficult.
- **Anesthesia.** Biopsies of lesions located in bone, in which the needle goes through the periosteum, and biopsies of tumors of neural origin are very painful. In such cases, US-guided anesthesia of the surface of the area to be biopsied is recommended.
- **Asepsis.** Careful attention must be paid to asepsia in the MSS, as the consequences of an infection (e.g. septic arthritis) may be serious. Although sterilization of the puncture site should suffice, the use of a sterile cover around the transducer is recommended in drainages and joint procedures.
- **Hemostasis.** Needle procedures in superficial locations, which are easily compressible, do not need specific hemostatic survey. However, hemostasis checking is advisable in catheter procedures and indispensable in patients with a history of coagulation disorders or on anticoagulant therapy.

**Specific procedures**

**Musculoskeletal biopsy**

Technical basis and principles of US-guided biopsy have been described in a previous article. Its indications are any musculoskeletal lesion of unknown nature, metastatic lesions of unknown origin, to exclude tumor recurrence after surgery, fat tissue lesions to rule out sarcoma, and infectious lesions to determine their specific etiology.

**Technique**

We always use automatic biopsy guns and, for most lesions, an end-cutting 18G needle, which allows different length samples (fig. 1). For fatty or soft lesions we find the TruCut type 14G needle more useful, and that is the one we usually use. These needles are also useful when 18G needles fail in obtaining the sample.

We should try to obtain representative specimens of the whole lesion in order to avoid sampling errors, for this reason, several punctures are recommended. We normally take three specimens from different areas of the lesion.

Sometimes, US guidance may also be used for bone biopsies when the lesion has breached the bony cortex allowing its visualization with US.

**Histological exam**

Specimens have to be fixed immediately for later processing, similar to other histological samples. We send the specimens in saline to the pathology department where pathologists make imprints that, along with the material obtained after centrifugation of the fluid used for the transportation, undergo cytopathologic test. Also, specimens are processed for

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Some US-guided interventional procedures in the musculoskeletal system</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percutaneous biopsies of musculoskeletal lesions</td>
<td></td>
</tr>
<tr>
<td>Arthrocentesis</td>
<td></td>
</tr>
<tr>
<td>Intraarticular injections</td>
<td></td>
</tr>
<tr>
<td>Drainage of abscesses</td>
<td></td>
</tr>
<tr>
<td>Drainage of hematomas</td>
<td></td>
</tr>
<tr>
<td>Treatment of bursitis</td>
<td></td>
</tr>
<tr>
<td>Therapeutic infiltrations</td>
<td></td>
</tr>
<tr>
<td>Sclerotherapy of cysts and cavities</td>
<td></td>
</tr>
<tr>
<td>Treatment of ganglia and Baker’s cysts</td>
<td></td>
</tr>
<tr>
<td>Treatment of tendinopathies</td>
<td></td>
</tr>
<tr>
<td>Treatment of calcific tendinitis</td>
<td></td>
</tr>
<tr>
<td>Treatment of Morton’s neuromas</td>
<td></td>
</tr>
<tr>
<td>Treatment of plantar fibromatosis</td>
<td></td>
</tr>
<tr>
<td>Regional anesthesia</td>
<td></td>
</tr>
</tbody>
</table>
histopathologic test. A histochemical or immunohistochemical test of the samples might also be performed 7.

Subtyping tumors and determining tumor grade in pathological analysis using these samples may be sometimes difficult as musculoskeletal tumors are usually heterogeneous and the sample might not be representative of the whole tumor 7.

Results
In general, the technique is very accurate in differentiating benign from malignant lesions, with a sensibility of 90 to 97 %, and a specificity of 98 to 100 % 7,9,10. Regarding the tumor grade, the technique is more accurate for high tumor grades than for low tumor grades 7.

Drainage of infected collections
Muscular abscesses may develop from surgical procedures, trauma, foreign bodies, and contiguous or distant spread of infections. Bursitis is the inflammation of the periartricular bursa, which sometimes may get infected. The technique and indications of this procedure have been described in a previous article 1 (fig. 2).

In 80 % of cases, percutaneous drainage in the MMS manages to heal the abscess avoiding surgery. In the rest, drainage helps control the infection and reduce its size, facilitating surgery and allowing elective surgery 2,11.

Factors related to higher failure rates are: presence of intracavitary bodies (foreign bodies, foci of myositis ossificans, bone fragments) where germs may linger causing recurrence of the infection, and associated infectious lesions in the adjacent bone (osteoemyelitis). Nonetheless, drainage of the collection associated with a focus of osteomyelitis generally allows healing of the primary infection focus 7.

Drainage of hematomas
Musculoskeletal hematomas are usually of traumatic origin or related to sports, although patients with bleeding diathesis or on anticoagulant therapy are more prone to hematomas. Asymptomatic hematomas only require conservative treatment until spontaneous resorption occurs. However, in symptomatic hematomas drainage may relieve the symptoms and reduce the healing time (fig. 3).

In traumatic hematomas or muscular fibre tears, drainage improves healing of the lesion and reduces the period of inactivity 2,11.

Technique
a. Hematomas:
Drainage technique is similar to that described for abscesses. The content of the hematoma varies from fluid collections to clotted hematomas. For fluid collections a small-bore catheter (7–8F) is adequate; however, long-bore catheters (12F) and fibrinolytic agents are recommended for coagulated content. We instill urokinase into the hematoma (100 000–250 000IU, depending on the volumen of the hematoma) every 8 h until the hematoma resolves or until there is no further reduction in volume (this usually takes 1-3 days) 7.

b. Minor muscular strains:
Prompt drainage of collections in the ruptured muscle promotes cicatrization. The aim is not to reduce the hematoma, but to prevent pseudocysts and promote cicatrization. These drainages may be done using 18-20G needles and punctures may be repeated if reaccumulation of fluid occurs 2,11.

c. Tennis leg:
Tennis leg is the muscular strain of the lower insertion of the inner gastrocnemius muscle. In severe cases, a fluid
collection appears between the gastrocnemious and the soleus causing functional impairment that may last several months. In these patients, drainage of the collection provides quick recovery. A fine catheter (6–7F) is placed inside the collection and left in until there is no fluid coming out during 48h. A scar will appear in the site. The sooner the collection resolves, the smaller the scar will be.

Precautions
Drainage is contraindicated if there is active bleeding. In such case, the drainage tube should be closed until the bleeding stops. Computed tomography (CT) and angiography are useful in the assessment of active bleeding and even in its treatment. Patients receiving oral doses of dicumarin need to change to heparin before the procedure.

Drainage must be performed with antibiotic prophylaxis using broad spectrum antibiotics. We use amoxicillin-clavulanic acid or cloxacillin. Due to the risk of venous thrombosis, a preventive dose of heparin is prescribed in tennis leg while the drainage is in place.

Results
Drainage may achieve clinical improvement and total or partial resolution of the hematomas in almost all the patients. In our cases, the drainage was maintained 1-13 days, but in 40% of rhem, it was maintained less than 72 hr. Catheter drainage of tennis leg usually allows the quick formation of a scar and sporting activity may be resumed in a few weeks, even after severe lesions.

Arthrocentesis
Arthrocentesis may be performed for diagnostic or therapeutic purposes. It might be performed without imaging guidance, but the reliability of the intraarticular injection performed in this way is low (32%)11. US-guided joint punctures help reach the synovial cavity in 97% of cases14. US guidance is particularly useful in obese patients, in small effusion, loculated effusions, dense effusions (fibrinous or hemorrhagic) or difficult to access lesions, such as the hip2,11.

Technique
The technique is similar to that explained in the general section. Once the needle tip is within the articular cavity, the content is aspirated. Local anesthesia is not required for arthrocentesis of superficial joints, but anesthesia of the path is recommended in deep joints. In young children sedation might be needed, particularly in hip procedures.

In case of dense articular fluid, 14-18G needles are more adequate. Thinner needles are preferred for intraarticular injection of materials.

The use of 7-8F catheters may allow drainage of joints when the high density of the fluid, the presence of fibrin films or septa or clots makes needle drainage impossible.

Substances for intraarticular injection
a. Corticosteroids for the treatment of several types of arthritis4,15,16.
b. Hyaluronic acid to improve joint lubrication4,15.
c. Urokinase helps drain effusions with fibrin septa or hemarthrosis, by lysing the fibrin and clots. In the knee, for example, we inject 100 000UI of urokinase dissolved in 30cc of saline and the fluid is aspirated after 1-2h2.
d. Gadolinium used for MR arthrographies7.
e. Synoviorthesis, chemical or radioactive, especially in small and difficult to access joints.

Specific approaches for individual joints
a. Shoulder.
The anterior approach is done with the patient in the supine position and the arm externally rotated. The needle follows the axial plane from the outside in, passing through the scapularis tendon. The posterior approach is done with the arm in maximum abduction, following the axial plane, from the outside in, passing through the infraspinatus muscle to the posterior labrum6,11,16-18.
b. Elbow.
The joint is punctured with the elbow flexed, from a posterior approach, following a longitudinal plane and directing the needle to the olecranon fossa of the humerus6,11.
c. Hip.
Puncture is done in the concavity at the junction of the femoral head and the anterior aspect of the neck, with
the patient in supine and the hip externally rotated and the needle aligned with the axis of the neck of the femur.\textsuperscript{6,11,16}.

d. Knee.
   The easiest approach is at the suprapatellar recess, with the patient in supine and the knee slightly flexed.\textsuperscript{6,11,16}

e. Ankle.
   The anterior approach is the easiest one, directing the tip of the needle to the tibio-astragalus joint, from a distal approach.\textsuperscript{6,11,16}

Specific precautions
- In septic arthritis, manipulation should be avoided and corticosteroid injections are contraindicated.\textsuperscript{4}
- Avoiding punctures of the articular cartilage.\textsuperscript{4}
- After intraarticular injection of corticosteroids, exercising the joint should be avoided for two weeks as well as avoiding the joint to bear weight for six weeks (table 2). These injections have been associated with damage and loss of cartilage elasticity in weight bearing joints.\textsuperscript{4,19}

Therapeutic infiltrations
Local injections of steroids are a standard practice in inflammatory or traumatic painful conditions of the musculoskeletal system. However, palpation-guided injections sometimes fail to target the lesion and, if performed within the tendons, may be very painful and may weaken them. US guidance allows accurate injection, increasing its effectiveness and reducing complications.\textsuperscript{2,20}

Technique
The puncture is performed directing the needle to the target. When injected, the spread of the fluid into the tissues may be visualized. Fine needles (22-25G) are recommended as they are less painful. Injections in inflamed articular bursa should be performed within the bursa. Infiltration of structures not covered by a sheath or bursa should be done on their surface. Injection of tendons, fascias or ligaments should be avoided in order to avoid their damage.\textsuperscript{2}

Several types of corticosteroids may be used; we usually use 40 mg of triamcinolone acetonide. Steroids combined with local anesthetics lead to an immediate, albeit short-term, pain relief. The results generally appear shortly after the infiltration. Sometimes, discomfort may appear at the injection site during the first 48 h. The infiltration may resolve the pain in patients without an underlying condition, otherwise recurrence is to be expected in the medium term.\textsuperscript{2,4}

Specific procedures
a. Treatment of Morton’s neuroma.
   Percutaneous treatment frequently avoids surgery and consists of alcohol, phenol or corticosteroid injections into the neuroma. We use corticosteroids as they act quickly and require only one or two injections.\textsuperscript{21,23}

b. Treatment of the piriformis syndrome.
   Two different approaches may be performed under US guidance: botulinum toxin injections into the piriformis muscle or corticosteroid injections into the periepierineural tissue around the sciatic nerve. With the patient lying prone, corticosteroids are injected when the needle reaches the periphery of the sciatic nerve, while botulinum toxin (around 200UI) is injected into the muscular belly of the piriformis.\textsuperscript{24,25}

c. Treatment of plantar fasciitis.
   US-guided infiltrations help minimize the risk of complications. The injection is done on the surface of the fascia without penetrating into it or injecting into the fat, so the injected material may be visualized spreading on the surface of the fascia\textsuperscript{26,27}.

d. Treatment ofLedderhose’s disease.
   According to our experience, an option that helps reduce the size of the fibromatosis and achieves complete symptomatic relief is the infiltration of corticosteroids into the whole lesion.

Precautions (table 2)
- **Methylprednisolone is recommended for superficial lesions.** Intradermal or subcutaneous corticosteroids, specially triamcinolone, may cause skin atrophy.\textsuperscript{4,28,29}
- **Intratendinous injections of corticosteroids should be avoided** as corticosteroids may damage the tendons and the injections are very painful.
- **Two weeks of rest and avoiding tendon-loading activities during 6 weeks is recommended after peritendinous injections.** Corticosteroids must be used carefully, particularly adjacent to bone-weighting (patellar, Achilles tendon) or injured tendons.
- **Corticosteroids are not indicated in the treatment of chronic tendinous lesions.**
• The injections need to be sufficiently spaced out, generally no less than 6 weeks, in order to assess their effects. No more than 3 injections should be performed in the same site in one single procedure, and the injection should not be repeated unless an at least 4-week symptomatic relief is achieved after 2 injections.6,13,14.
• Diabetic patients should be warned of the hyperglycemicant effect of corticosteroids.

Treatment of ganglia

Most ganglia are asymptomatic and do not require treatment or even resolve spontaneously. Nonetheless, many are symptomatic due to compression of adjacent structures and need treatment. Sometimes, treatment is required for cosmetic reasons. Surgery has a recurrence rate of up to 34%.35 Puncture of these lesions with US guidance shows similar recurrence rates than surgery. As ganglion content is extremely dense, large-bore needles (14G) are recommended for its drainage. In order to completely drain the collection, performing several lavages with saline should be useful. Although there is no consensus, complete treatment of the ganglion may be completed with corticosteroid injection into the lesion to reduce recurrence rate.6,16,36,37 We have used absolute alcohol with good results (the cavity is filled with alcohol that is aspirated one hour later). This technique is very effective in the short term; nonetheless, it has a significant rate of recurrence. The treatment may be repeated.6

Treatment of bursitis

Bursitis may appear as thickening of the walls of the joint bursa, as fluid collections or, in case of an infection, as pus collections.

The treatment of choice for inflammatory bursitis is corticosteroid injections into the bursa. In case of intrabursal collections of fluid, this must be drained before the injection. 14-18G needles are adequate. Treatment of infectious bursitis is similar to that described for abscesses and corticosteroids are contraindicated.6

Treatment of Baker’s cysts

Baker’s cysts are sometimes symptomatic because of inflammation, rupture, intracystic hemorrhage, and increase of the internal pressure or compression of adjacent structures, sometimes mimicking thrombophlebitis of the leg. In such cases, US-guided percutaneous treatment may palliate or resolve the symptoms.19

The cyst must be drained in order to resolve the compression on the adjacent structures. An intracystic injection of corticosteroids is recommended after drainage. We use 40mg of triamcinolone acetonide. Treatment is very effective in the short term, especially in patients with pseudothrombophlebitis. Although the recurrence is frequent if there is an underlying condition, we can improve the symptoms in most cases.1,4,16.

Aspiration of calcific tendinitis of the shoulder

Although frequently asymptomatic, 50% of patients suffering from calcific tendinitis experience pain that may be severe, highly incapacitating and go on for years. In general, it is a self-limited condition, but during the spontaneous healing process the calcifications release into the subacromial bursa causing extremely severe pain followed by a painful, incapacitating and prolonged bursitis. Conservative treatment is usually ineffective and surgery, although effective, is not without complications and needs a long recovery period. A simple, inexpensive and very effective alternative is the percutaneous aspiration of calcifications.6,19-41

Aspiration should be reserved for symptomatic calcific tendinitis. There is no need to treat those calcifications in which the calcium has passed into the subacromial bursa, since the puncture will have no effect on the natural progression of the condition.

Treatment technique

The calcification should be visible on x-ray and US. Using both techniques allow identification of concomitant conditions that might have an effect on the progression of the patient and need specific treatment. Premedication with alprazolam helps prevent faint spells and convulsions (in patients prone to them). We have observed that muscular young men are more prone to fainting. The patient is seated with the hand behind the back. When the tendon involved is the subscapular (fig. 4), the patient lies supine with the arm in external rotation and in abduction. The syringe should remain below the calcification. For this procedure we use a 20G intramuscular needle connected to a Luer-lock syringe initially filled with lidocaine 1%.

The needle is inserted following the direction of the tendon fibers, from its insertion towards the muscular belly and is introduced into the calcification after anesthetizing the path. Once inside, the calcium deposit
should not be aspirated; instead, the syringe plunger must be forcefully pushed until a small amount of lidocaine enters the calcification. At this moment, the patient might feel moderate pain. If we do not manage to inject lidocaine, we should pull the needle back to the edge of the calcification where injecting is possible in most cases.

We perform repeated short injections, releasing the pressure after each injection allowing the fluid to flow back into the syringe, dragging the calcium. When the fluid in the syringe becomes cloudy, we replace it with a new syringe filled with saline and the procedure is repeated until the fluid comes out clear. For large calcifications, several syringes may be needed. Sometimes, particularly in small calcifications, it might not be possible to aspirate any calcium, but this does not imply a treatment failure since the calcification might disappear in the following weeks.

Puncturing the same calcification in different sites is better to be avoided. In case we need to remove a needle (i.e. due to needle obstruction) we should leave it in place as we are using another one, until the procedure ends. As a general rule, if we are using more than one needle, none of them should be removed before the end of the procedure. Once the procedure is concluded, steroids are injected in the subacromial bursa and the patient is discharged without any special prescription. Treatment can be repeated if the symptoms or rests of calcification persist.

**Results**

Patients usually experience discomfort 24-48 h after the procedure. Most patients experience a complete symptomatic relief, which generally lasts at least one or two months or may even be permanent.

In 40% of the patients the initial improvement is followed by worsening of the symptoms 2-3 months after the treatment and lasting a mean of 6 weeks. Late recurrence of the symptoms is associated with slightly worse long-term results.

One year after, 51% of the patients have no symptoms and 40% reported a near complete improvement. The calcifications disappear completely in 78% of the patients and almost completely in 11%. The best results are obtained in large and dense calcifications, especially those located in the supraspinatus tendon. On US scans the acoustic shadowing disappears but an area of high echogenicity persists in the treated zone.

**Treatment of tendinosis**

Tendinosis are degenerative changes within the tendons that involve fibroblast and vessel infiltration. Clinical characteristics include tendon thickening, pain and vascularization increase.

Several techniques have been proposed for treating tendinosis: sclerosis of neovessels, intratendinous injections of platelet-rich plasma or injections of an irritant solution in order to promote fibroblastic proliferation in the tendon. Although these techniques usually provide clinical relief, multiple sessions are required and there is currently no clear evidence of their effectiveness.

**Foreign body removal**

US may be useful to guide the insertion of a hook-wire localizer close to the fragment to guide surgery. Also it is possible to remove the foreign body using US-guided forceps (fig. 5).

Injecting saline around the fragment under US guidance is recommended to separate the foreing body from the surrounding tissues and improve its visualization making it easy the procedure of removing it. Metal fragments and stones are easy to remove, whereas wood, glass and, especially, fragments of animal origin require great skill.

**Figure 5** A) Fluid collection in the back of a patient who reports secretion through a cutaneous fistula since she underwent surgery for a pilonidal cyst. US image shows a lineal image in the shape of railroad tracks. B) Latex drainage tube extracted from the collection and the forceps used in the procedure performed with US guidance.
Authorship

Jose Luis del Cura has made contributions to the conception, design and drafting of the manuscript and to the acquisition, analysis and interpretation of data.

Rosa Zabala has made contributions to the analysis and interpretation of the data as well as to the critical review of the paper.

Igone Corta has made contributions to the acquisition of data and to the critical review of the manuscript.

All the authors have read and approved the final version of the article.

Conflict of interest

The authors declare no conflict of interest.

References