# Module 1. Diagnostic imaging in team sports medicine

## Unit 1.1 The Use of Ultrasound and Magnetic Resonance in Muscle Injury by Sports Physicians

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Items:

1. Use of imaging in sports medicine and its relation with radiology.
2. Clinical use of ultrasound.
3. Role of MRI in the classification of muscle injuries.
4. Role of imaging tests in return to competition and the assessment of re-injury.
5. Ultrasound-guided procedures in muscle injury.

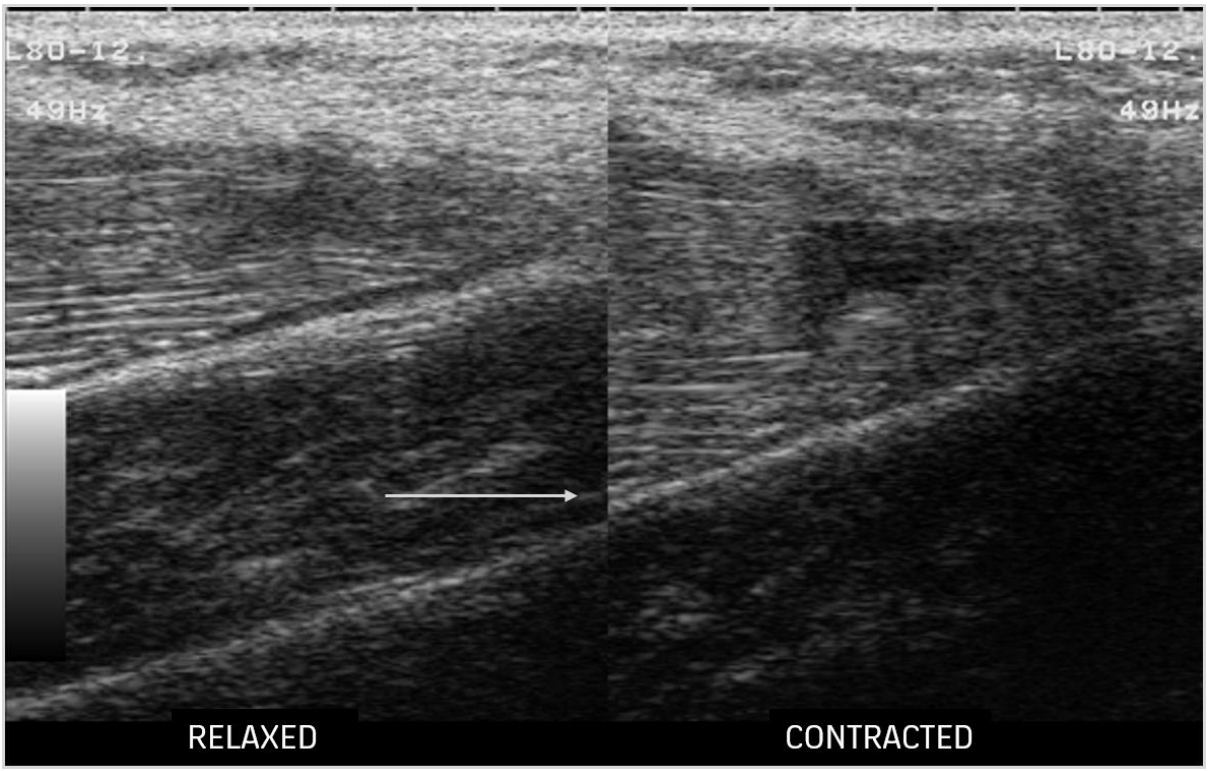
Diagnostics imaging is a tool that sports physicians should use to be more accurate when diagnosing, prognosticating and treating muscle injuries. In this way, sports physicians and radiologists should work together in order to optimise the images of sports injuries to the fullest in order to get a diagnosis that is as accurate as possible.

In this unit we want to answer some frequent questions in this area, so you have a clear idea on how magnetic resonance, and especially, ultrasound can help the sports physician in their diagnosis and prognosis.

### 1. Use of Imaging in Sports Medicine and Its Relation with Radiology

Ultrasound image is less sensitive than MRI image, but, on the other hand, ultrasound has a lower cost and allows monitoring the injury observing its evolution, or detecting complications. Another advantage of using ultrasound for muscle injury recovery is the ability to perform a dynamic assessment before and after a muscle contraction. This could either represent or not a persistence in the alteration of the fibre after rehabilitation or clinical treatment (Figure 1). This is very important when assessing mild or severe muscle injuries that condition the athlete to return to practice.

**Figure 1: Myofascial Injury in Distal Third of Rectus Femoris**




Source: Prepared by the author

Note: Longitudinal dynamic section. On the left image the patient is relaxed, while in the image on the right, the rectus femoris is contracted and the tear is clearer (arrows).

Diagnostic imaging is key to confirm and assess the relevance of muscle injuries in sports. It contributes to the decision-making process as regards the treatment which directly affects the prognosis and return to competition. Currently, ultrasound and MRI are the most frequently applied techniques in sports medicine. As a result, the prognosis based on the clinical information available together with the information obtained in the diagnosis imaging is key.

Sports injuries constitute a very important aspect of the day to day of sports physicians. A well-performed diagnosis needs a good medical history, a good physical examination and the performance of some image procedure that confirms the clinical diagnosis. This procedure could be conventional radiography, ultrasounds, scan (CT), planar bone scan (PBS), or magnetic resonance (MRI).

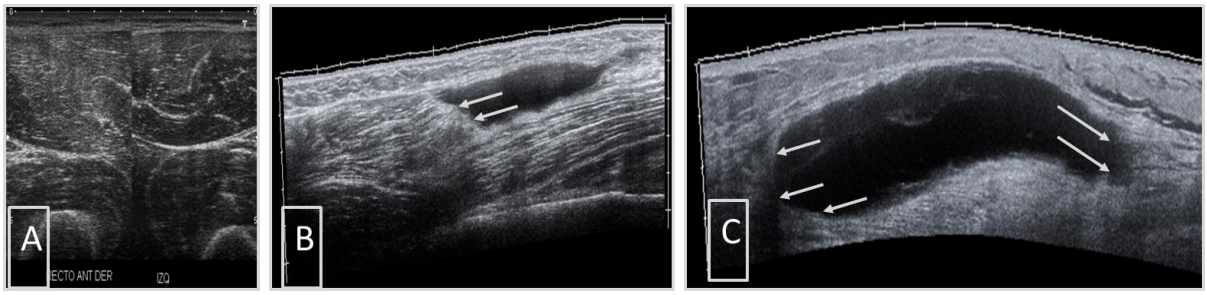
Until now, radiologists were in charge of doing the corresponding assessment of the ultrasound. However, it is more often proposed that team physicians are trained to use this tool, so there is a better diagnosis and prognosis of the injuries.

Sports physicians should perform ultrasound assessments of their athletes up to the limits their knowledge allows them. When they reach this point, they should turn to a radiologist with a degree in musculoskeletal pathology in order to re-assess the ultrasound or to

include other imaging tests. In conclusion, the ultrasound is shared by sports physicians with a solid clinical base and high ultrasound knowledge, and the radiologists who have a solid base in diagnosis together with the clinical knowledge of the patient.

It is very important to obtain the best diagnosis in a muscle injury in order to determine the severity related to the time when not practising the sport. (Figure 2).

**Figure 2: Three Degrees of Muscle Injury in Ultrasound**




Source: Prepared by the author

Note:

A Degree 1. Increased echogenicity is observed in rectus femoris (*). The image on the right is the contralateral image.

B Degree 2. Fluid collection that partially takes up biceps femoris muscle (arrows)

C Degree 3. Fluid collection that fully dissects a complete tear in the medial head of the gastronecmius.

This is why the collaboration between sports physicians with expertise in muscle injuries and in ultrasounds, and radiologist specialised in musculoskeletal with degree in sports injuries is key.

## 2. Clinical Use of Ultrasound

Assessment done with ultrasound is part of the routine clinical examination in many specialities. In this way, radiologist Wayne W. Gibbon (1) in 1998, foresaw what lately happened in some nations, and what is happening now in many others. This is due to a variety of factors. All of them are related to the evolution of the ultrasound technique from the end of the last century until the present.

The first factor is the technological one. Ultrasound equipment has higher frequency transducers which allow a more efficient visualisation of the structure of the musculoskeletal system. That is why, currently, it is easy to assess nerves, tendons, muscles and joints with great accuracy. Besides, this ultrasound equipment is smaller and smaller, which makes their portability and management possible.

The second factor is the economic one. With the improvement of the equipment comes a reduction in the costs. As a result, today it is easy to access to a quality ultrasound

equipment in any medical consultation. This is enough to perform a diagnosis and to devise a plan for the patient.

The third factor is the professional one. The medical knowledge that professionals of the musculoskeletal system currently have is really high. They also show a high responsibility towards their patients. Immediate clinical information obtained about the musculoskeletal system with the ultrasound, and its subsequent monitoring make this technique interesting for the physician, and beneficial for the patient. The use of ultrasounds in routine medical practice should be similar to a cardiac auscultation in a cardiac examination, or to an ultrasound in obstetrics.

In this situation, it is logic that the company offers sonographers, which are high-end and have reasonable prices, to the physician who has the need to use the ultrasound in order to improve the quality of their medical practice to benefit their patients.

As a result, in many countries, especially in Europe, the physician normally performs an ultrasound. Cardiologists and gynaecologists have always performed controls on their patients with this technique. The incorporation of diverse medical specialities to the musculoskeletal ultrasound has been gradual and unstoppable. From decades, rheumatologists have gone deep into the ultrasound of the musculoskeletal system, and progressively, sports physicians, anaesthesiologists and physiatrists have become interested in the use of this technique. Today is the turn of orthopaedic physicians.

Paradoxically, at present, the greatest limitation of the use of ultrasound is in the learning of the technique and not in its accessibility. In this way, ultrasound technique requires a higher learning curve and a lower cost each day. This fact means that, many times, in spite of its extraordinary clinical use, it is wrongly used. This is why responsible and mature health professionals who want to use this technique do not want to do it for free, and in a trivial way, but in regulated and serious way instead.

### 3. Role of MRI in the Classification of Muscle Injuries

For the assessment of these anatomopathological details of muscle injury, MRI is considered to be better than ultrasound. So, ultrasounds should adapt their findings to the classifications done through MRI. The MRI, especially the one done with 1.5-3.0 Teslas equipment, contributes to obtaining high-quality images of the muscle architecture, and of the muscle injury. In this way, the level and the extent of the involvement of the myo-connective tissue is assessed. The assessment of the degree and location of the affected extracellular matrix is key to offer a reliable prognosis. The more damaged the connective tissue is, the bigger the functional impairment, and the worse the prognosis. These details should be objectified by the classification of muscle injuries.

The main problem in the diagnosis and prognosis of muscle injury is the lack of consensus on the classification of the muscle injury. This is due to the difficulty that imaging tests still present when assessing the real alteration of the muscle architecture and the degree of

the injury. Besides, when suggesting a classification from a prognosis perspective, the type of activity the athlete does, and its causing mechanism should be taken into account.

Recently, three classifications have been proposed:

**1)** Munich Consensus Classification (Mueller-Wohlfahrt et al. 2013).

**2)** British Classification System (Pollock et al. 2014).

**3)** FCB Barcelona and Aspetar Classification (Valle et al. 2017).

These classifications are oriented to different factors which are key to obtain a better diagnosis and prognosis. Some of them are based in performing high-quality MRI images. They mention some of the following points:

**1)** Injury mechanism.

**2)** Injury location.

**3)** Involvement of the myo-connective bond: tendinous, myofascial, musculotendinous, or intramuscular.

**4)** Fibres retraction.

**5)** Oedema extension (cross section area).

**6)** First injury of re-injury.

## 4. Role of Imaging Tests in Return to Competition and the Assessment of Re-injury

On the other hand, at least for now, there is no strong evidence that proves that ultrasound or MRI are useful to predict the time in which the athlete will be in the right conditions to return to the sports activity. Evidence in the world of sports medicine shows that the standardisation of the increase in the intensity of the signal in MRI images is not necessary for a successful return to the sports activity. At the same time, it suggests that functional recovery is predicted by a structural recovery based on the diagnostic imaging. (Figure 3).

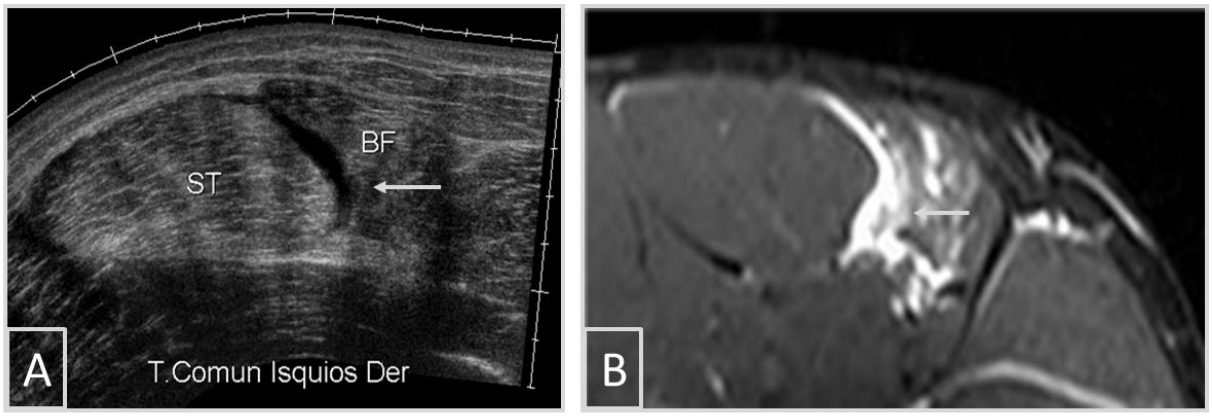
**Figure 3: fsT2 axial MRI in upper third of right thigh at the level of the central tendon of rectus femoris**


Source: Prepared by the author

Note: Fibre repair of central tendon (arrows) with paracicatricial oedema is observed (*). The athlete was asymptomatic and has returned to competition without re-injury.

There are diverse criteria for the use of MRI or ultrasound in relation to return to competition. In the first place, the return to the sports practice of an athlete should be based on a positive clinic, based on pain examination, flexibility, fatigue, strength, being the diagnostic imaging a support tool only. In the second place, through an ultrasound and/or MRI the injury could be diagnosed and monitored not to see its positive evolution towards repair, but to direct it to detect complications earlier. (Figure 4).

**Figure 4: Injury of conjoint tendon of hamstrings (arrows), objectivised through imaging tests**




Source: Prepared by the author

Note: A: Cross-section ultrasound in medial upper third of semitendinosus ST right thigh.

BF: Biceps femoris.

B fsT2 axial MRI in upper third of right thigh.

Ultrasound, according to our experience, is good to monitor the recovery process and to control haematoma, fibrosis, muscle architecture repair, among others. It is cheaper and more useful but, doubtlessly, it is not the best indicator to decide when the athlete should return to sports activities.

On the other hand, there is not enough evidence that supports the use of MRI to identify athletes who are under a greater risk to be injured again. The decision about the return to competition and the risk of re-injury is not a matter that should be assessed with a single tool, but with a combination of all of them. In this way, clinical assessment and other tools like GPS values should help to make the final decision about readiness of an athlete to return to the activity.

**5. Ultrasound-guided Procedures in Muscle Injury**

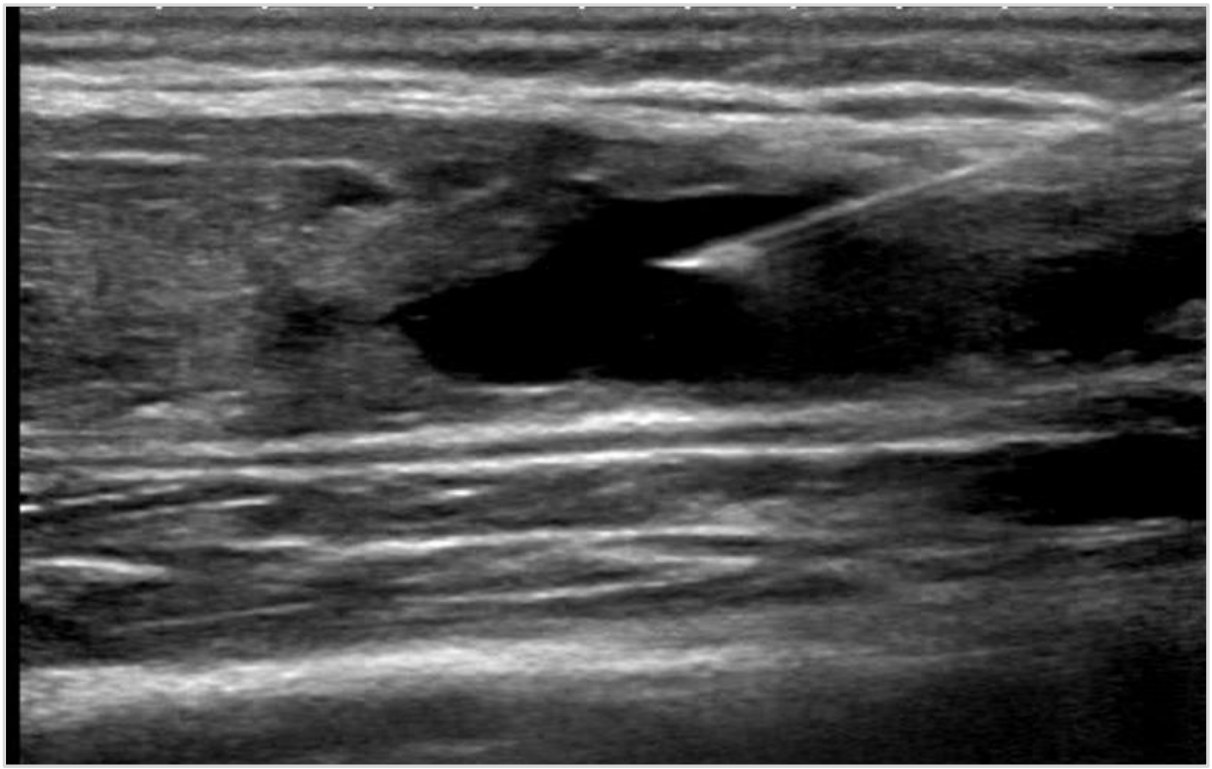
Ultrasound in muscle injury also has a therapeutic role. The technique should be meticulous and regulated. Ultrasound-guided puncture could be performed in two clearly differentiated situations: on one hand, in acute injuries, and on the other, in chronic injuries.

The aim of ultrasound-guided puncture of an acute injury is to reduce the tension of the affected muscle segment. So, we will only prescribe a puncture when haematic-fluid collection involves, or there exists a clinical risk of, a distal neurovascular compromise. Corticosteroids are never infiltrated. Empirically, recently, some procedures use infiltration of platelet-rich plasma in acute injuries in order to reduce the time of biologic tissue repair. Results of these experiences are not available yet.

Chronic muscle injuries in which an ultrasound-guided treatment could be performed are fibrous scars, cystic bruise, and Morel-Lavallé lesion.

Fibrous scar should be infiltrated making holes with the needle in the area of fibrosis. If this is done using ultrasound-guided equipment, it could be difficult since needle control would not be possible when moving it constantly. This is why it is better to locate the zone with an ultrasound and calculate the depth and the area to infiltrate. It is an indirect ultrasound-guided puncture. Cystic bruise is usually observed in myofascial injuries, usually in tennis leg, and in injuries in the semitendinous distal bond of the rectus femoris. The aspect of the haematic aspiration indicates us how old it is. So, if we extract blood, we will know that the injury, or relapse, is recent. If we extract blood plasma, the injury is old. Puncture-aspiration of Morel-Lavallé lesion obtains a variable but usually relevant quantity of almost not dense, yellow and blood plasma fluid. In most of these procedures, it is essential to put a circular or pressure bandage after the puncture. (Figure 5).

**Figure 5: Ultrasound of a longitudinal section of an injury of rectus femoris in posterior fascia with haematoma and fibre repair (*)**



Note: It is a re-injury. Ultrasound aspires the residual haematoma, and a PRP ultrasound-guided injection is performed.

Source: Prepared by the author

**Future Challenges and Techniques**

The most advanced MRI techniques available for muscle assessment are not frequently applied in the clinical practice. This is why, it is necessary that the expert who works in

the clinical area promotes the direct contact with the radiologist, and consults the latter about new techniques to get a better diagnosis and prognosis. In this way, for example, from a sports medicine perspective, the improved mapping in T2 Mapping could be useful. T2 values increase in stressed muscles, and could help us to know the activation or changes in muscle recruitment after muscle injuries.

Also, images performed with diffusion tensor imaging allow the quantification of the diffusion of anisotropic tissue, and allows us to observe the direction path of the muscle fibre in order to detect a lesser injury, and to be able to differentiate injured muscles form those that are not.

On the other hand, ultrasound is beginning to include elastography or shear-wave in the usual protocols in order to study the physiological reaction of damage or healthy bones. In fact, it was discovered that there is a difference in the rigidity of muscles after an injury.

In a close future, it is probable to include positron emission tomography (PET) with the aim of achieving greater knowledge about metabolic and functional muscle changes, and the relationship between the before and after of a muscle injury together with the recovery process.

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